Reconocimiento de Patrones

Version 2022-2

Árboles de Decisión

[Capítulo 4]

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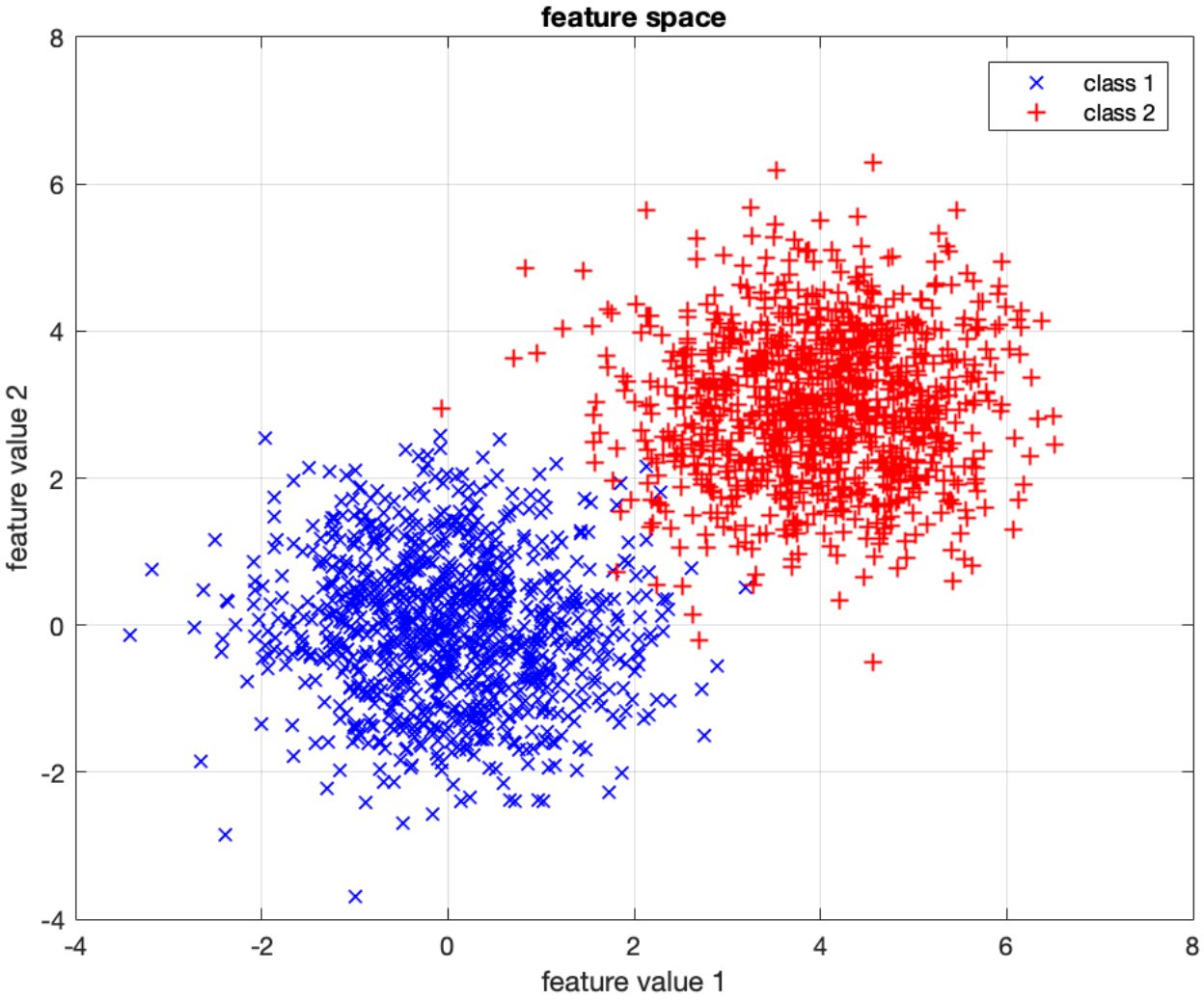
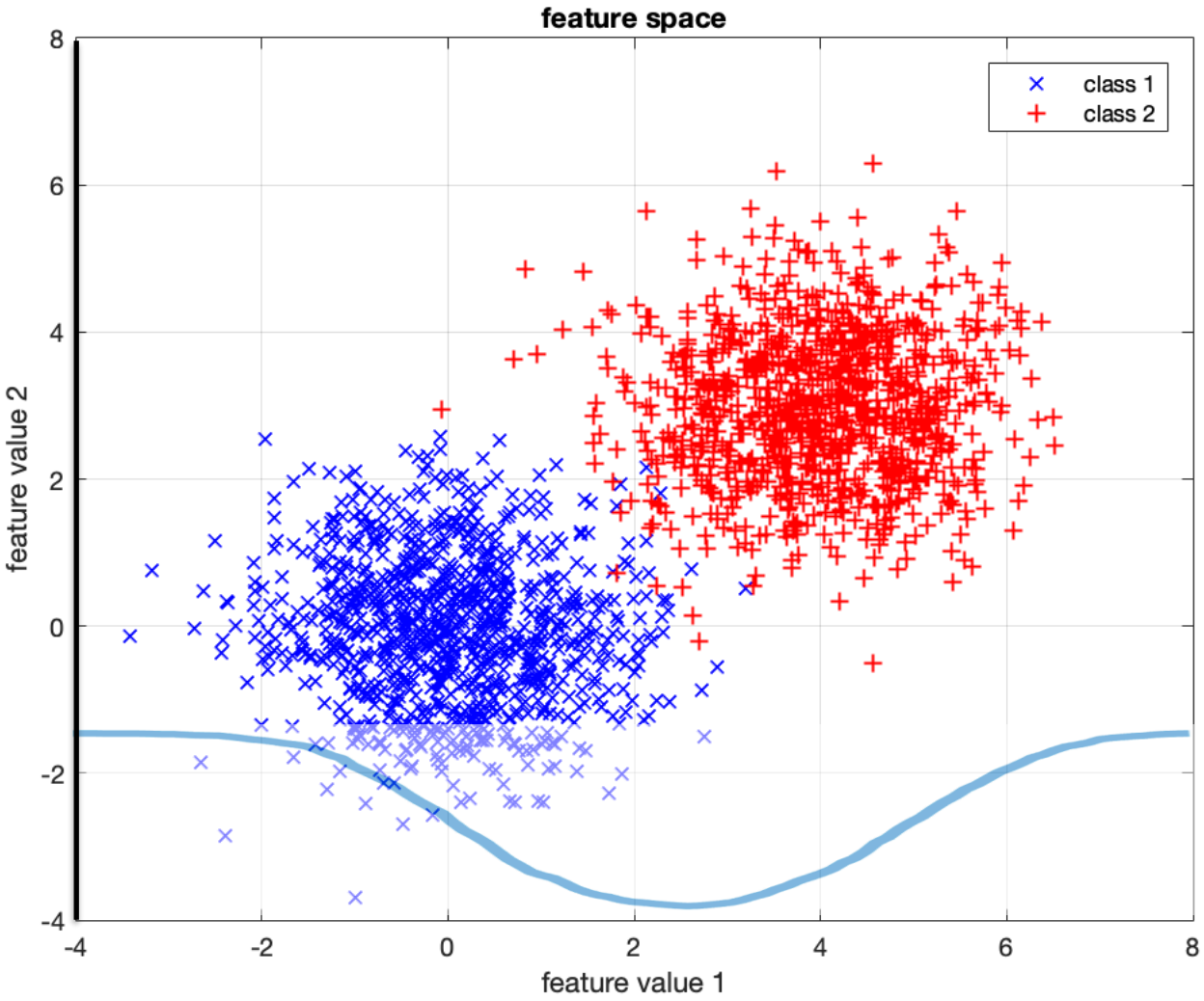
Árboles de Decisión

Árboles de Decisión (Training data)

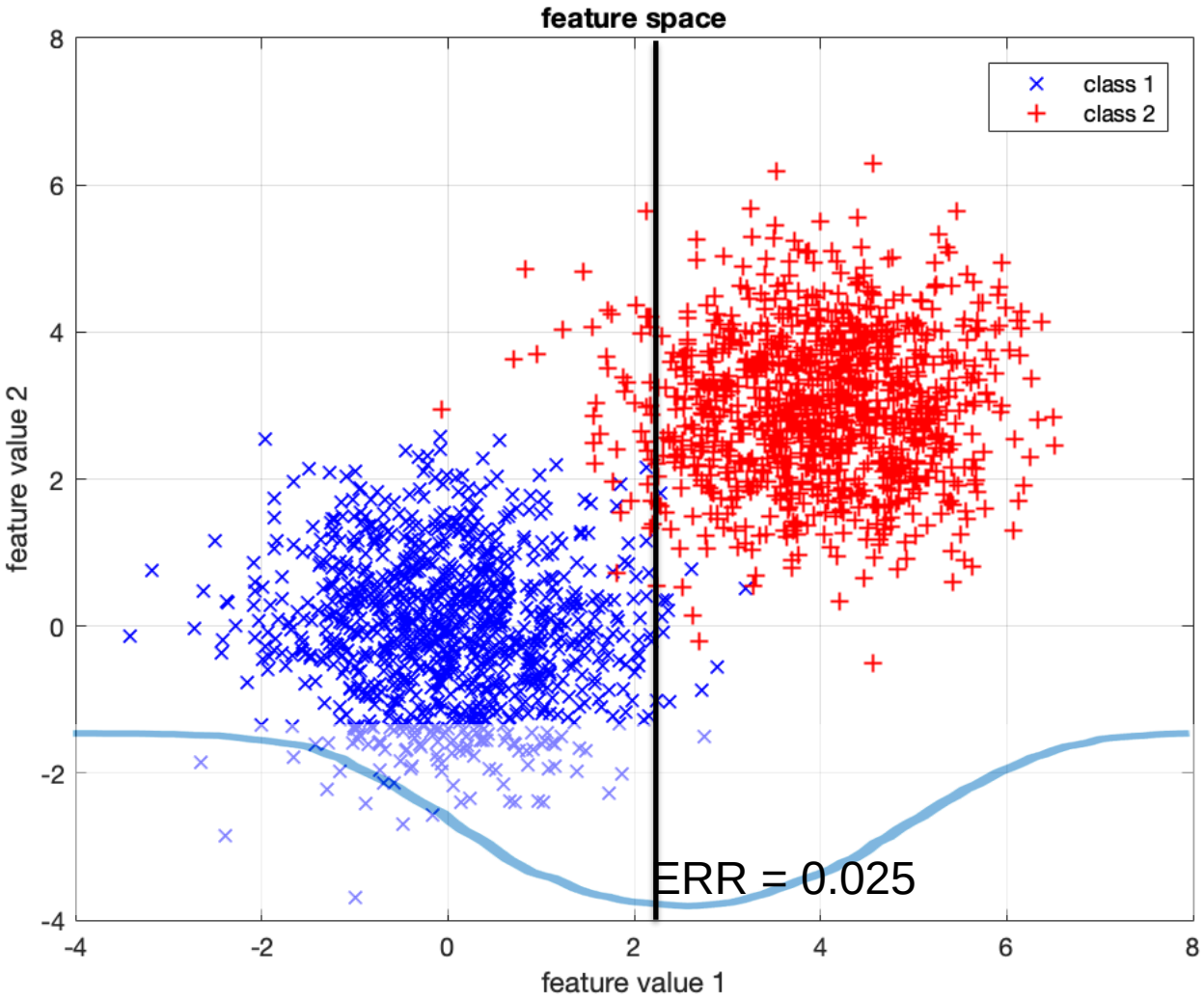


Árboles de Decisión (Training data)

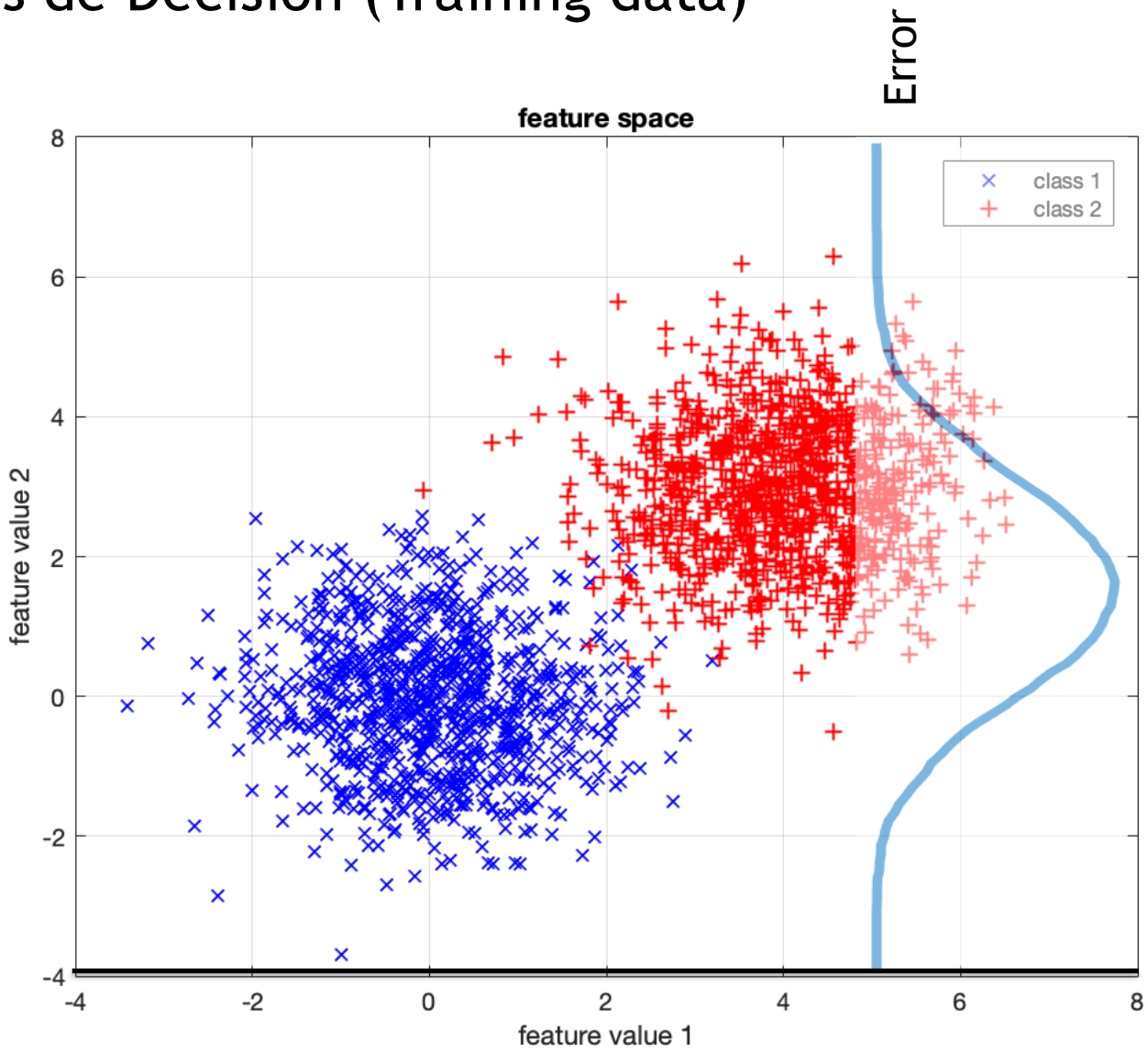


Error

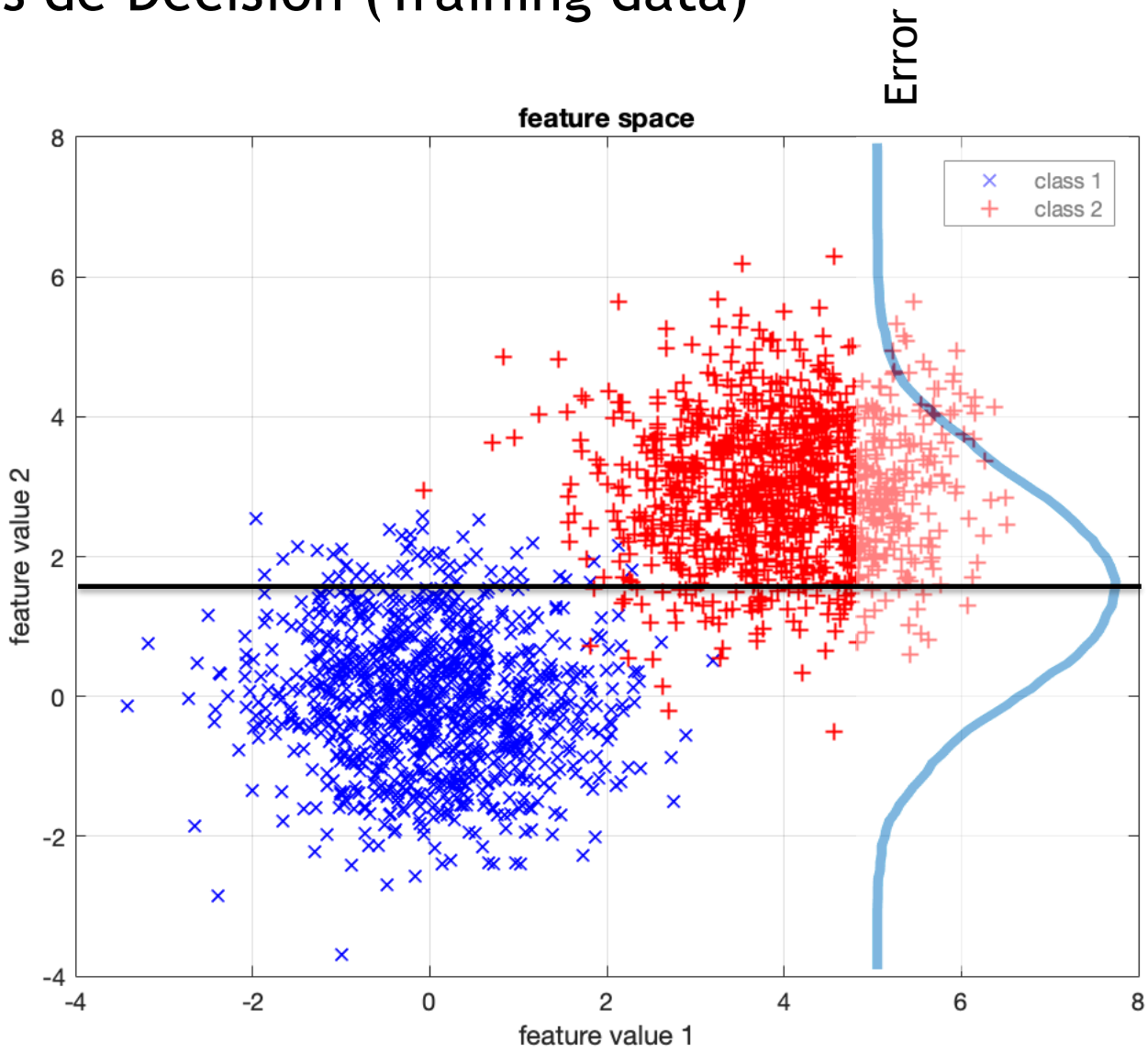
Árboles de Decisión (Training data)



Árboles de Decisión (Training data)

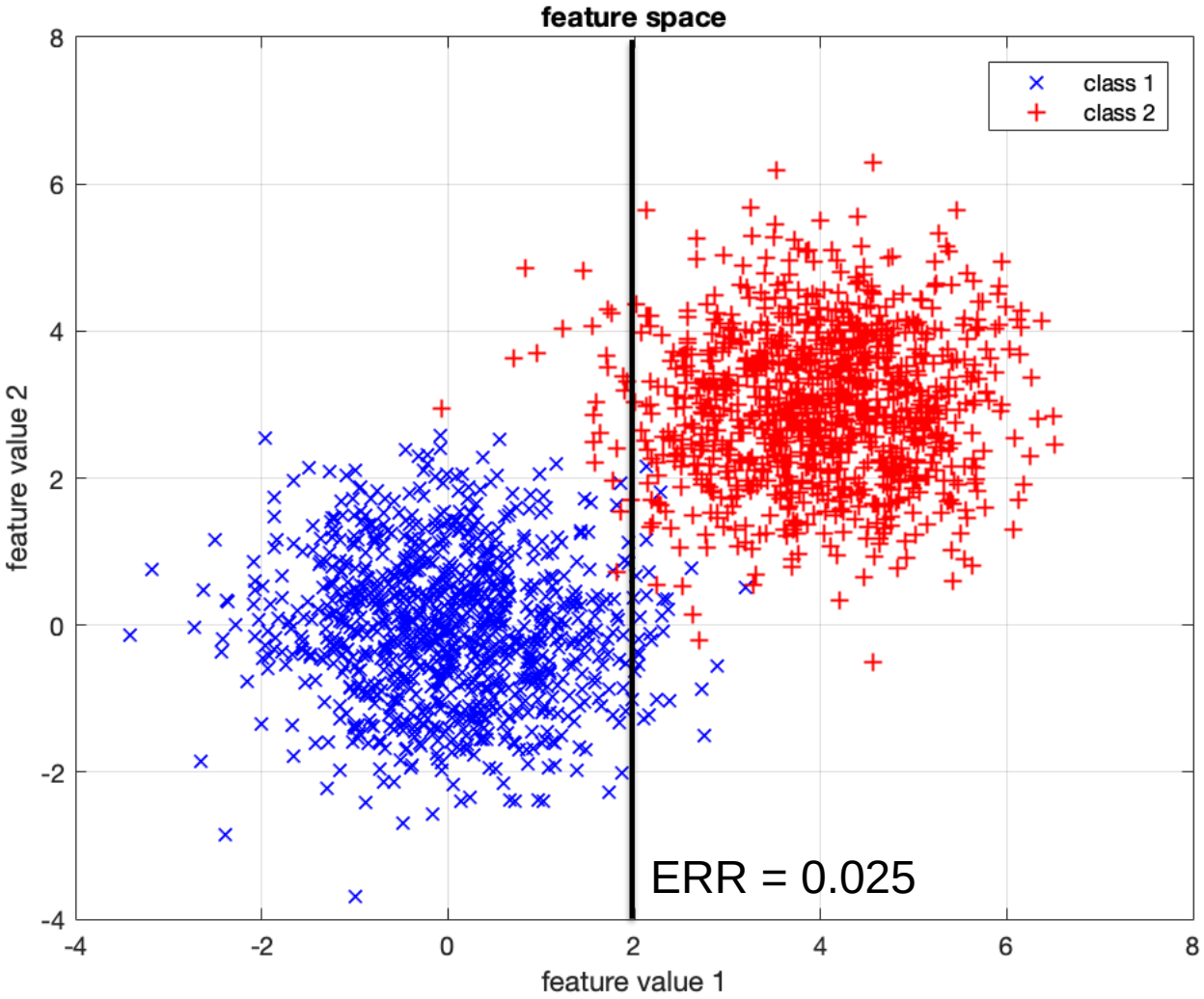


Árboles de Decisión (Training data)

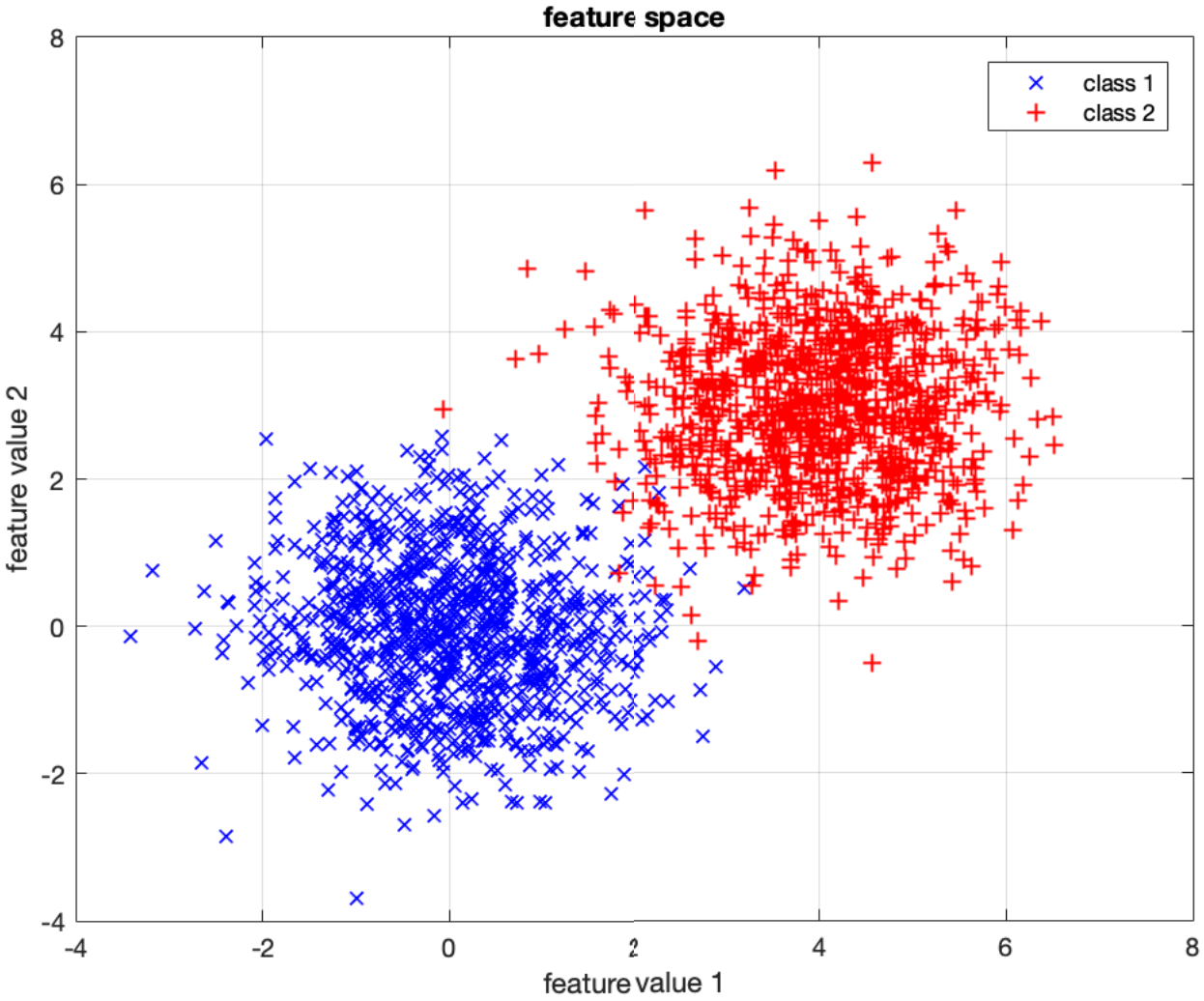


ERR = 0.066

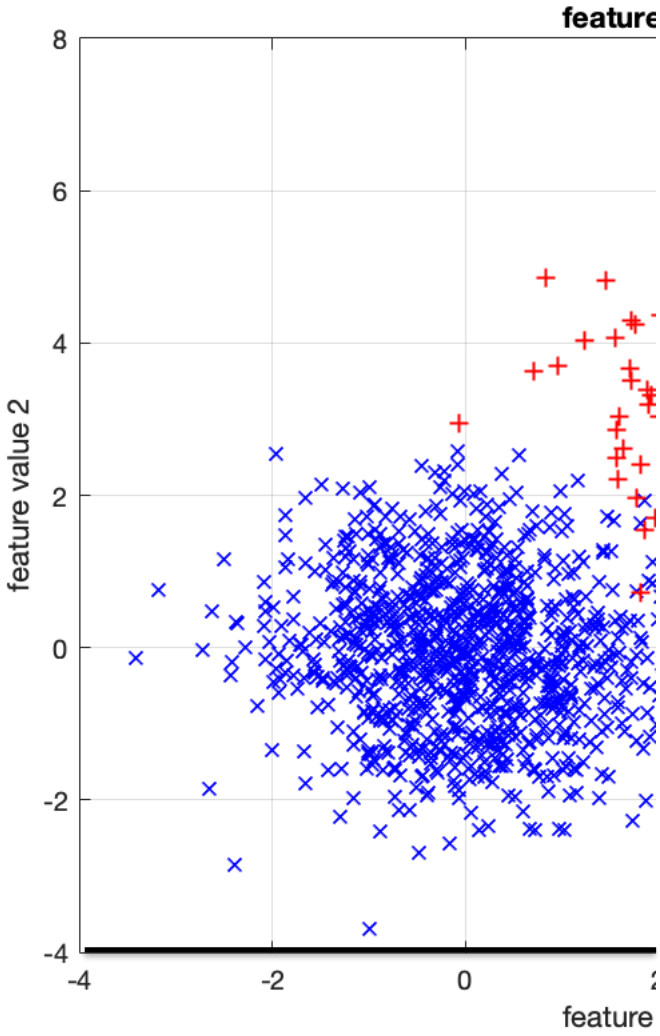
Árboles de Decisión (Training data)

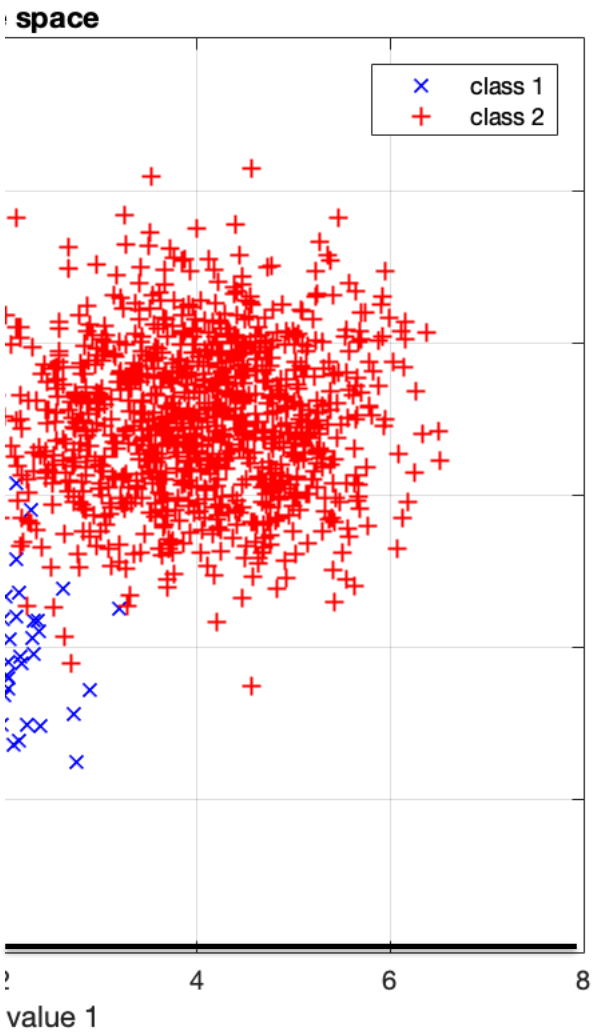


Árboles de Decisión (Training data)

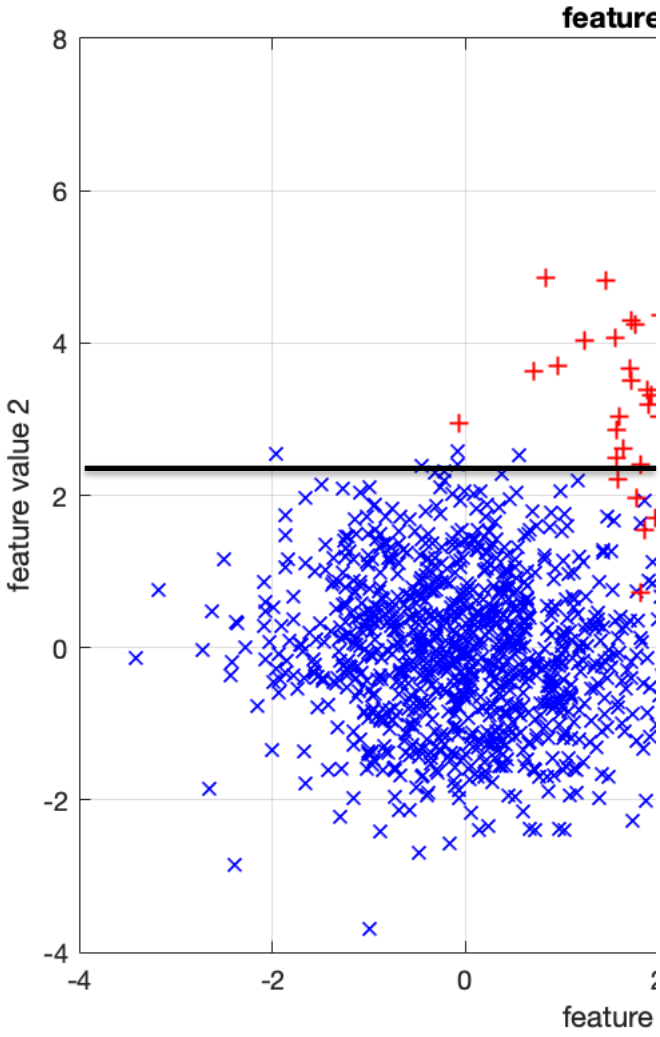


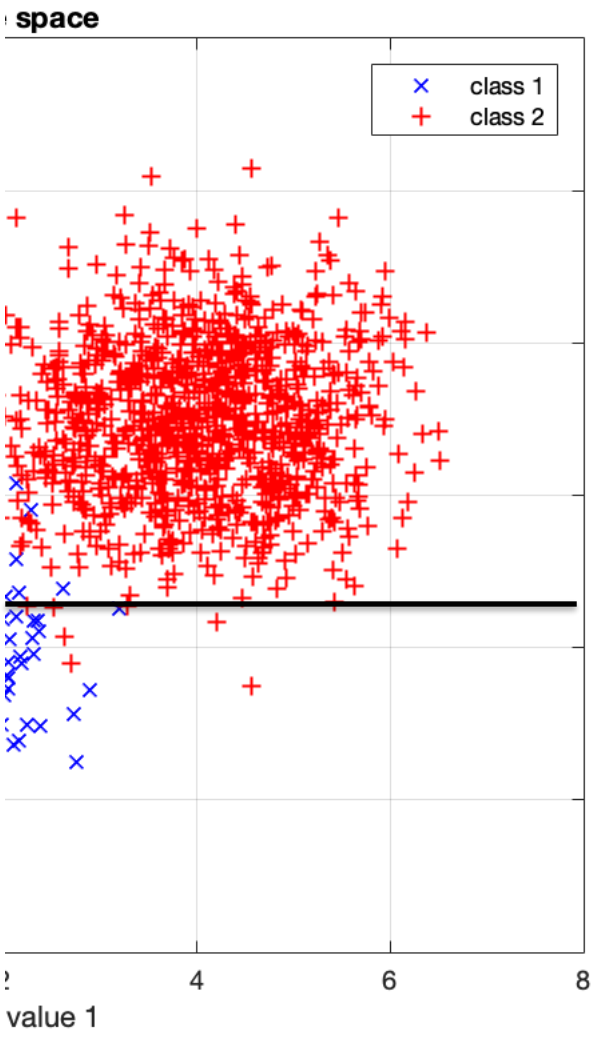
Árboles de Decisión (Training data)



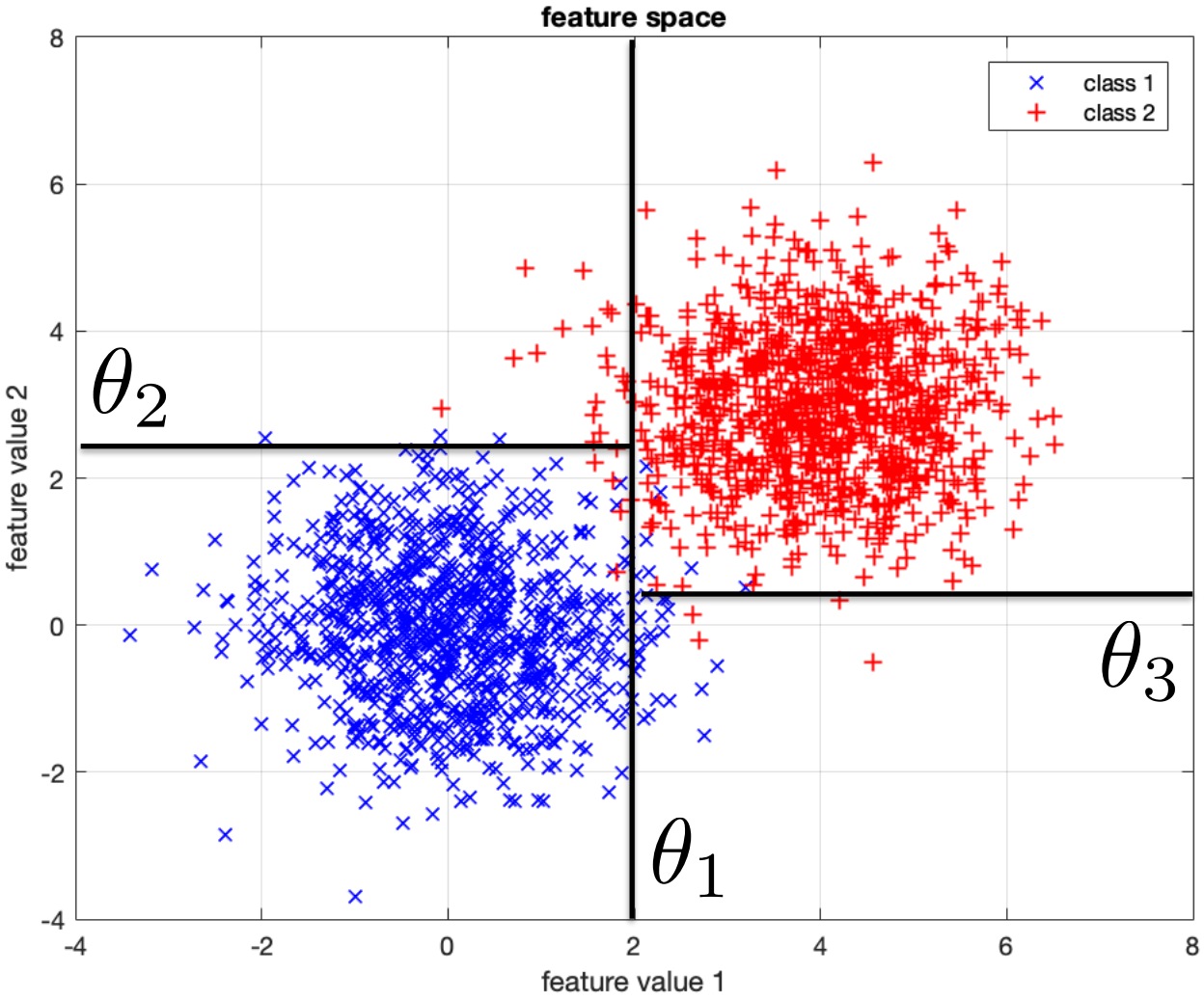


Árboles de Decisión (Training data)



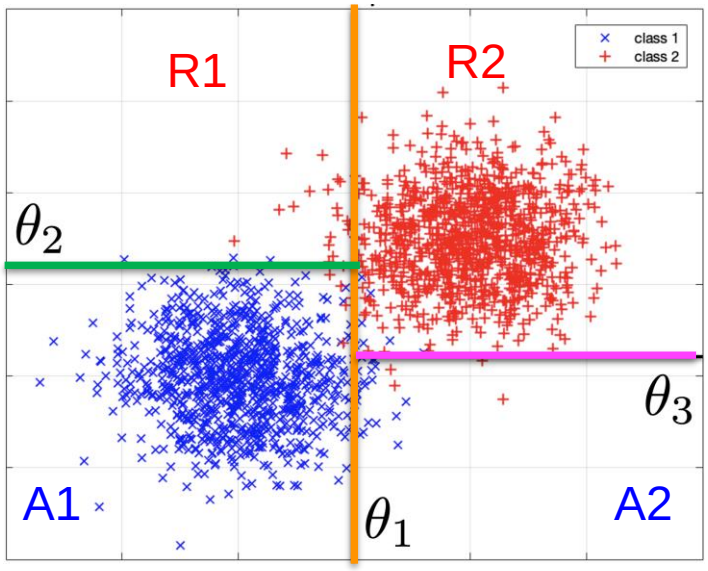


Árboles de Decisión (Training data)



etc...

Árbol



$x_1 > \theta_1$

No

Sí

$x_2 > \theta_2$

$x_2 > \theta_3$

No

Sí

No

Sí

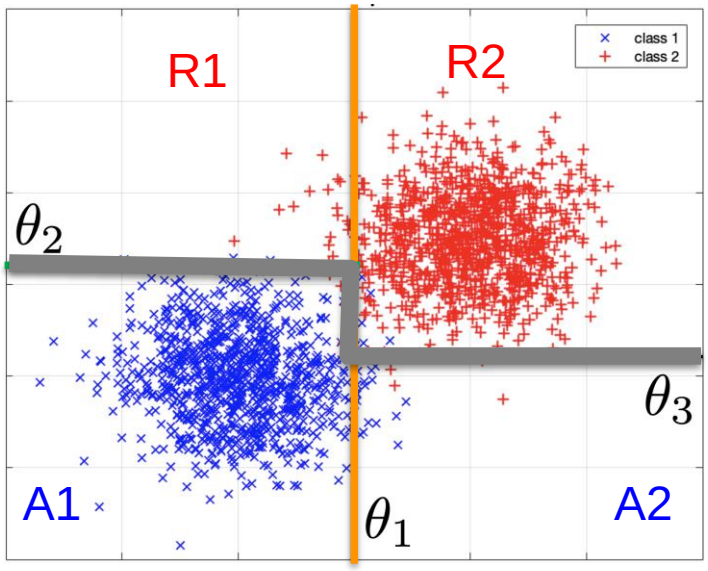
A1

R1

A2

R2

Árbol



$x_1 > \theta_1$

No

Sí

$x_2 > \theta_2$

$x_2 > \theta_3$

No

Sí

No

Sí

A1

R1

A2

R2

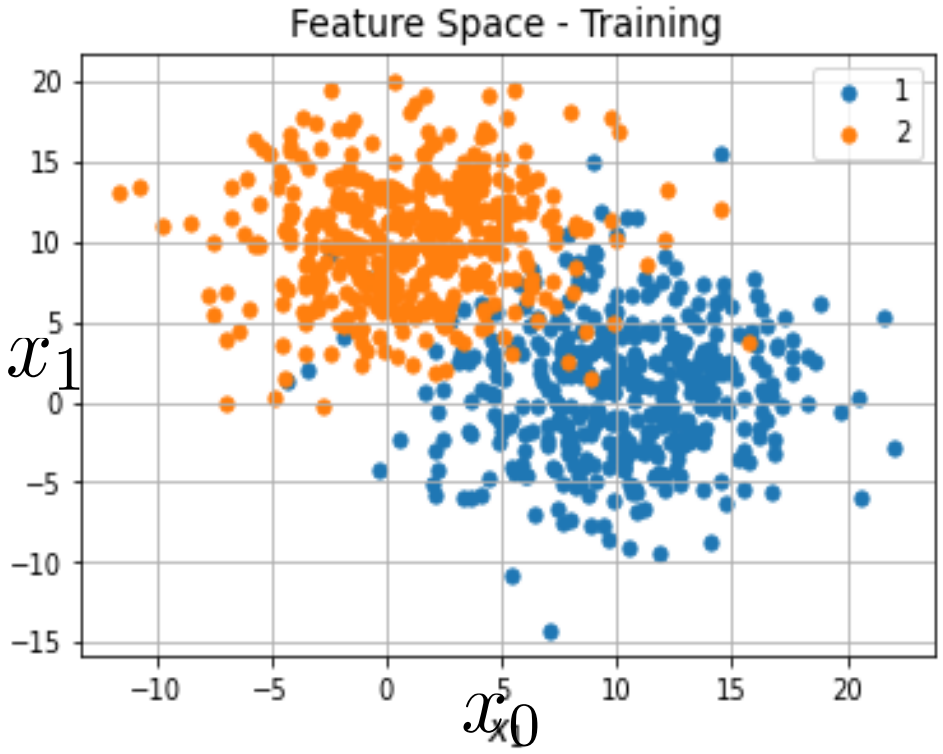
Métricas usadas para el error:

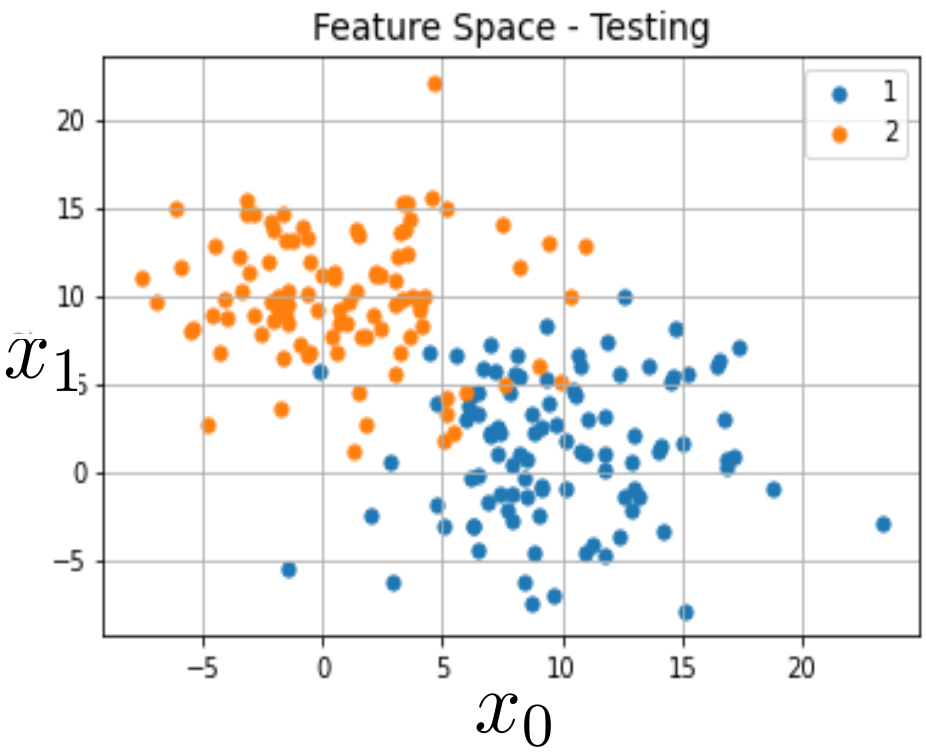
- Error de clasificación 1 - Accuracy
- Entropía $$-\sum_{k=1}^{K} p_k \log_2(p_k)$$
- Índice Gini $$\sum_{k=1}^{K} p_k(1-p_k)$$

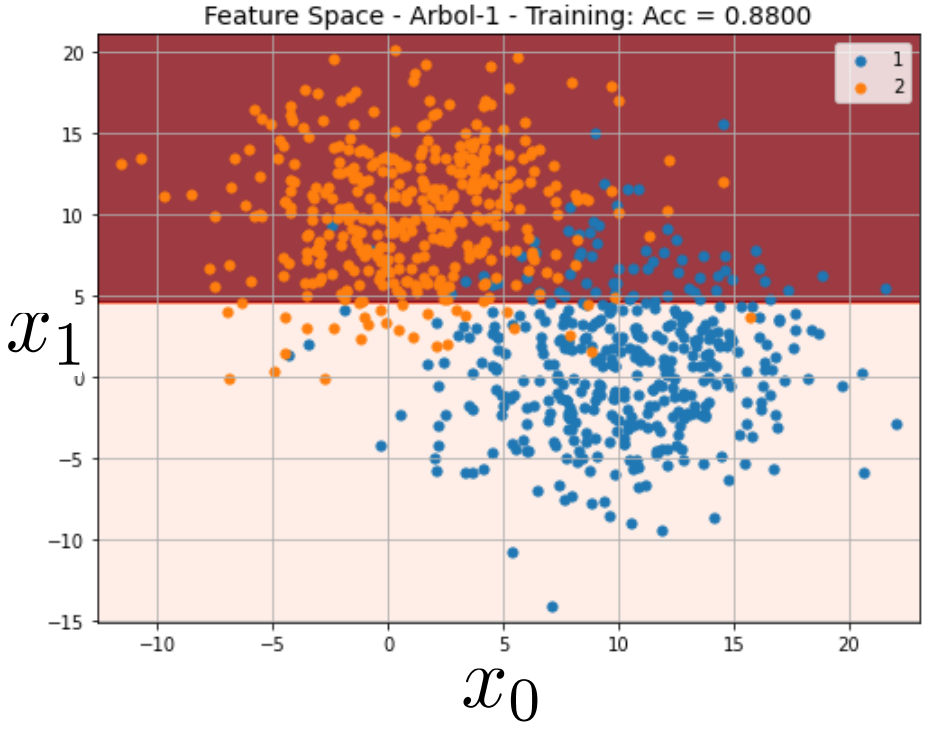
p_k Probabilidad de clasificar bien la clase k

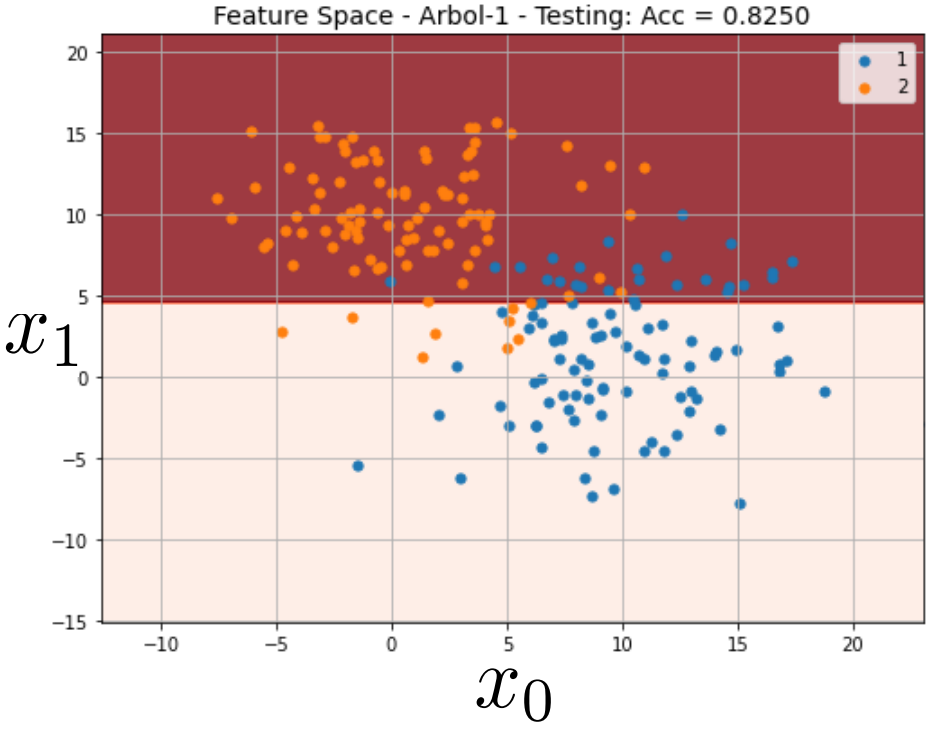
EJEMPLO

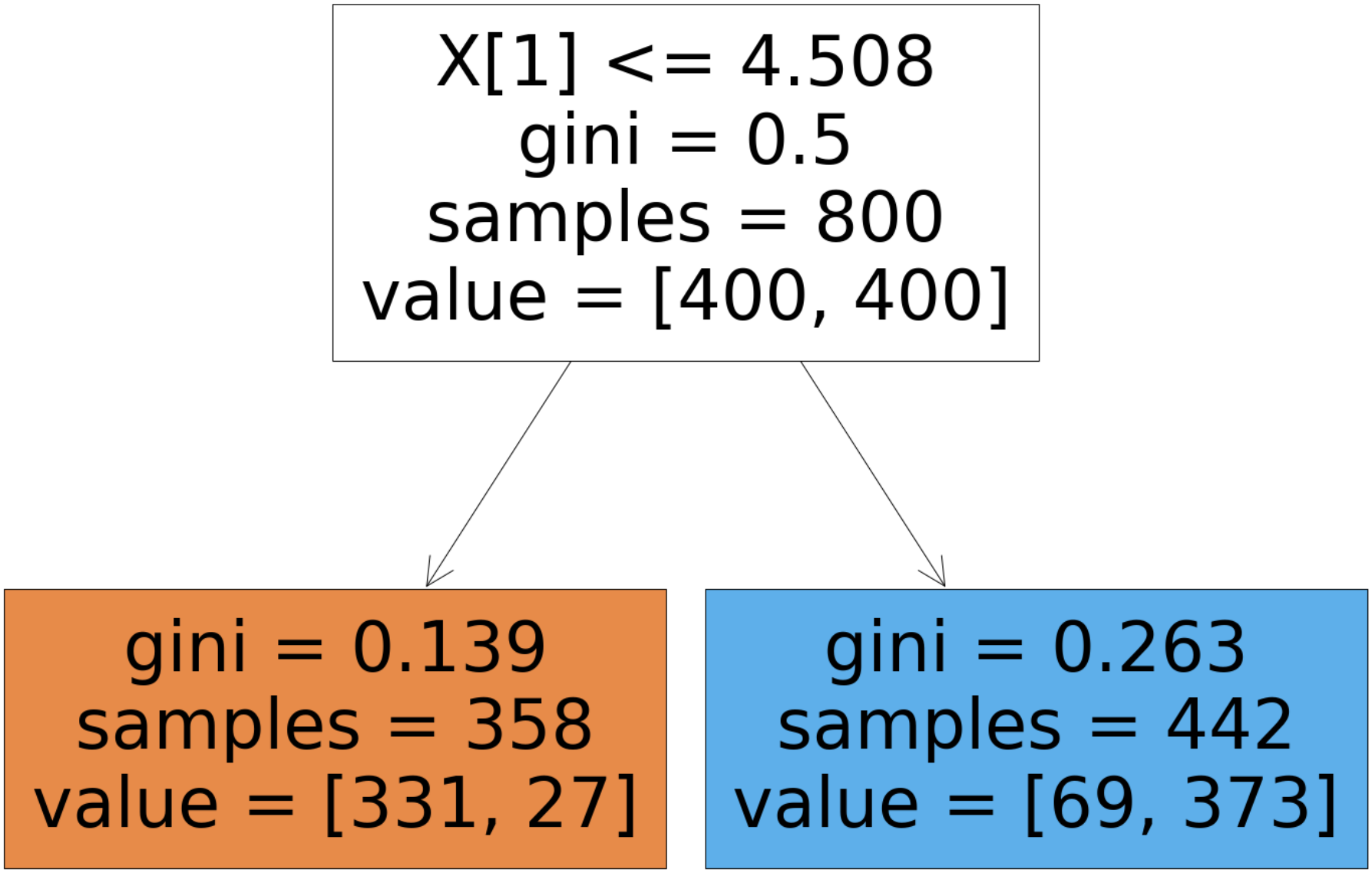
Datos Training/Testing

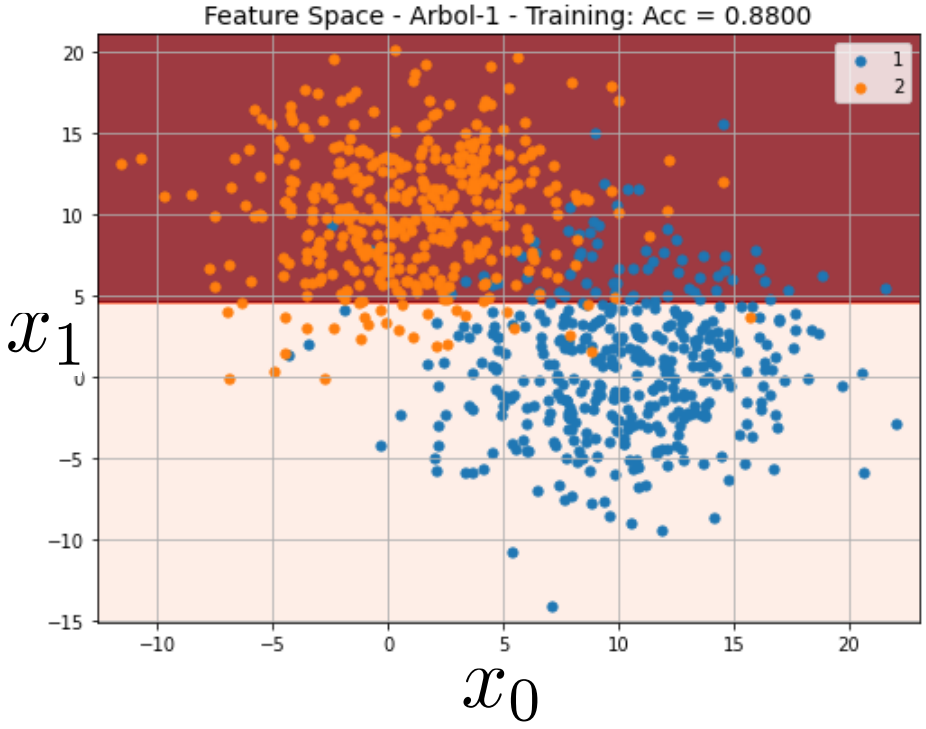


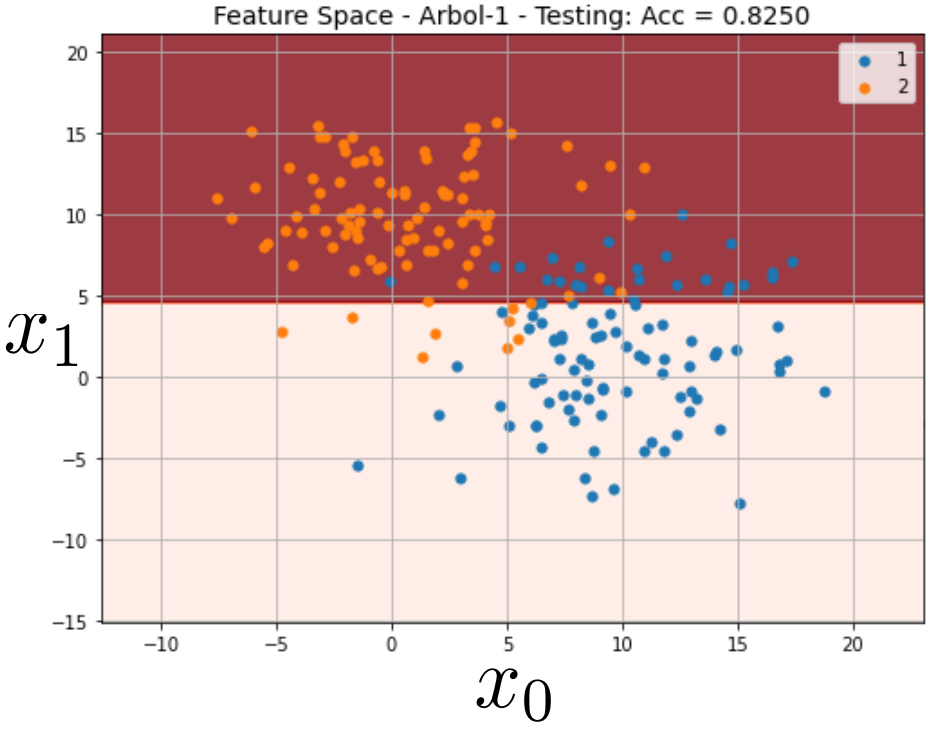


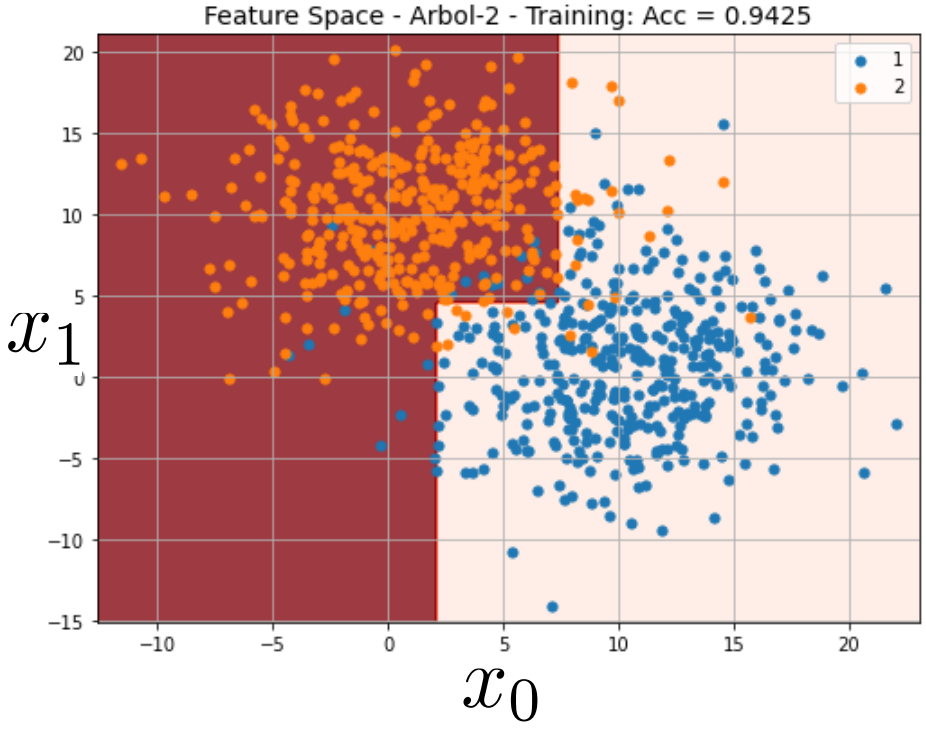

Feature Space - Arbol-1 - Training: Acc = 0.8800
1
2
20
15
10
5
0
−5
−10
−15
−10
−5
0
5
10
15
20
x_1
x_0

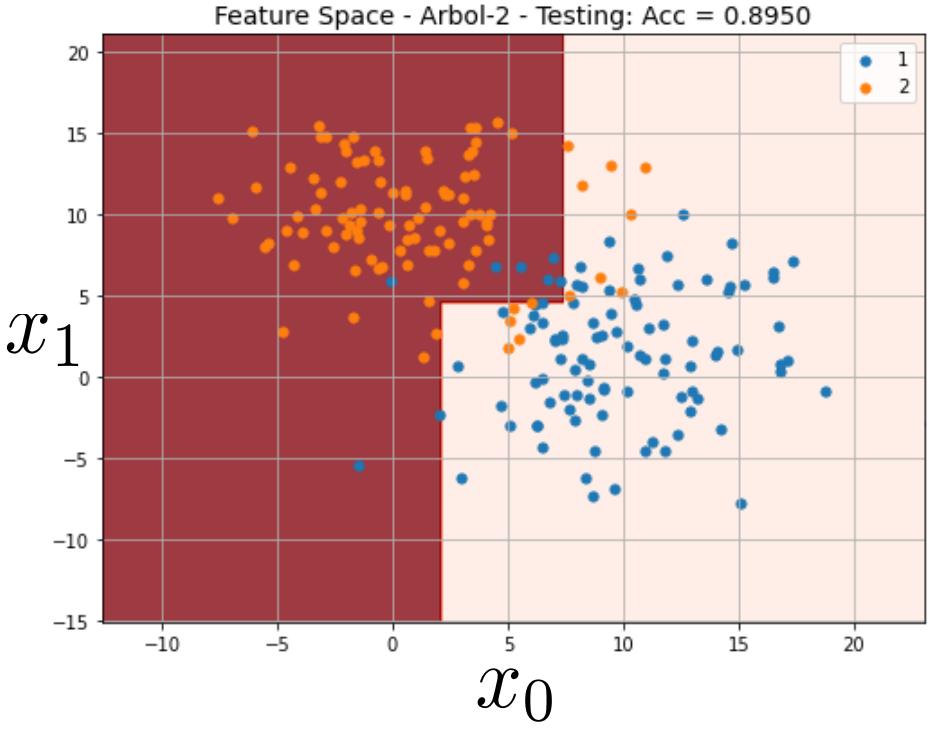

Feature Space - Arbol-1 - Testing: Acc = 0.8250
1
2
20
15
10
5
0
−5
−10
−15
−10
−5
0
5
10
15
20
x_1
x_0

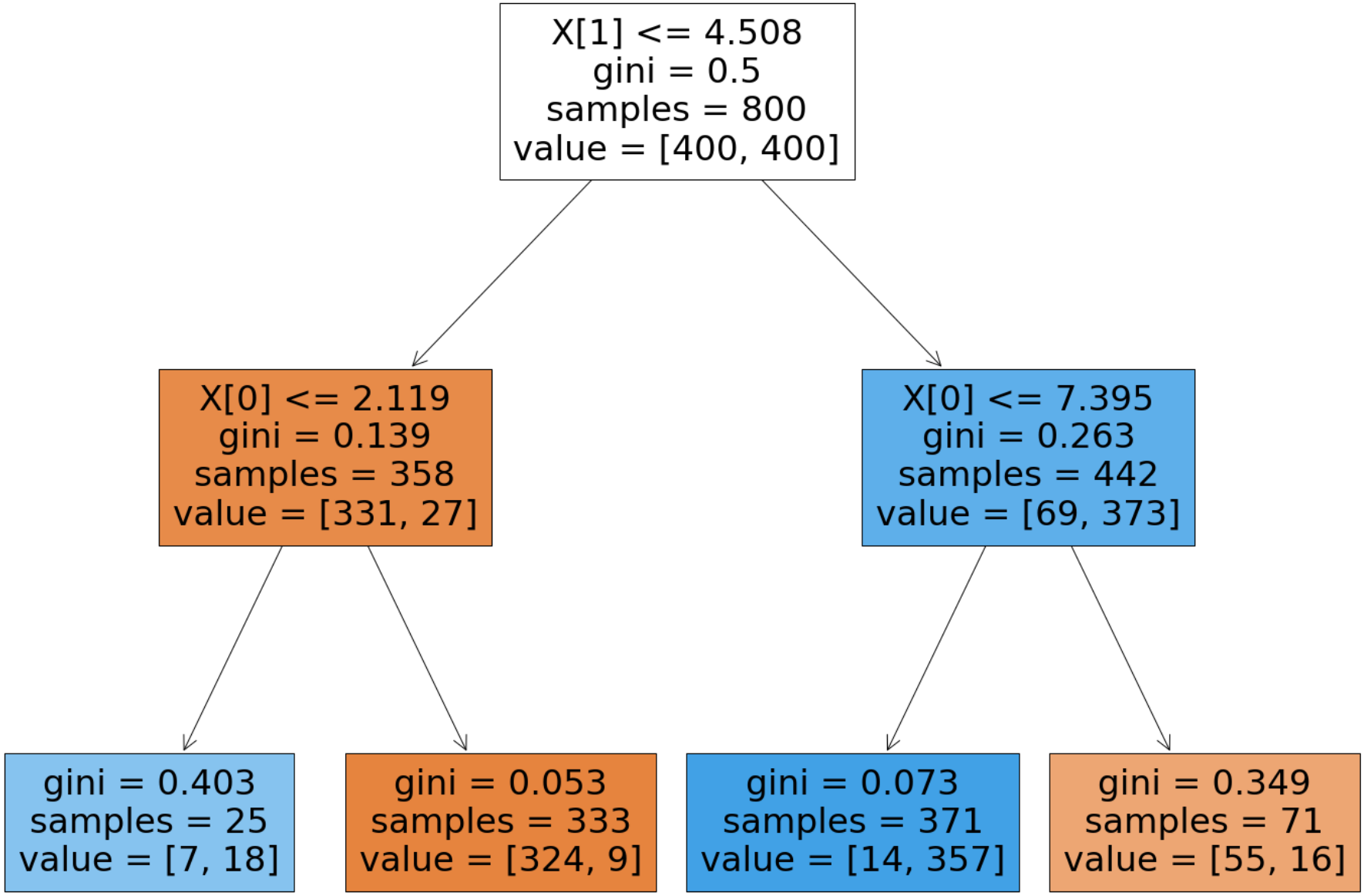

X[1] <= 4.508
gini = 0.5
samples = 800
value = [400, 400]
gini = 0.139
samples = 358
value = [331, 27]
gini = 0.263
samples = 442
value = [69, 373]

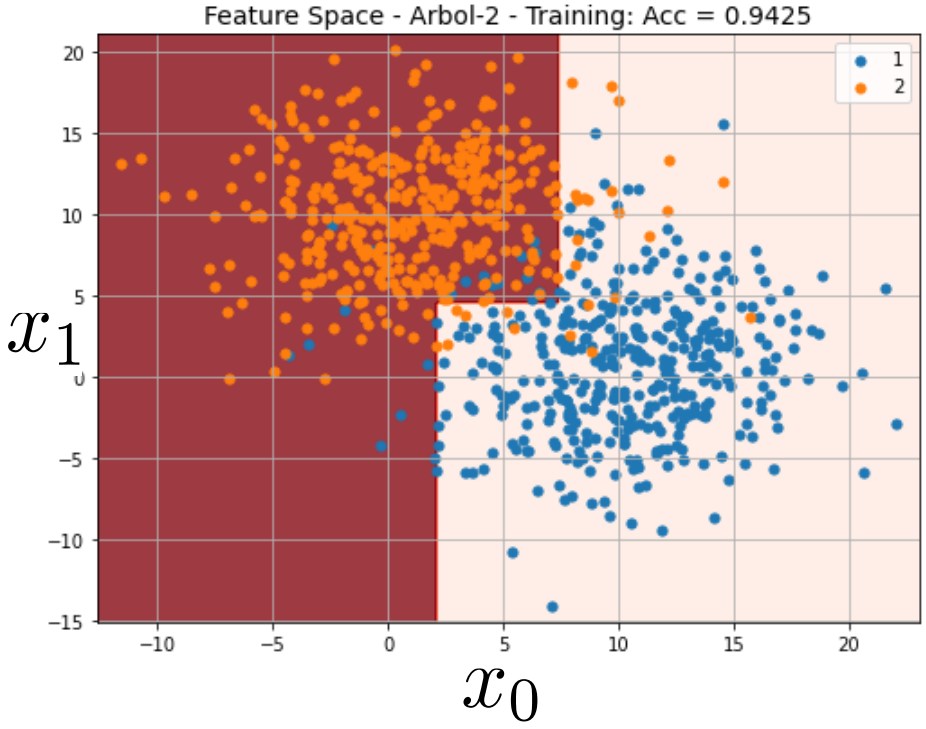

Feature Space - Arbol-1 - Training: Acc = 0.8800
1
2
20
15
10
5
0
−5
−10
−15
−10
−5
0
5
10
15
20
x_1
x_0

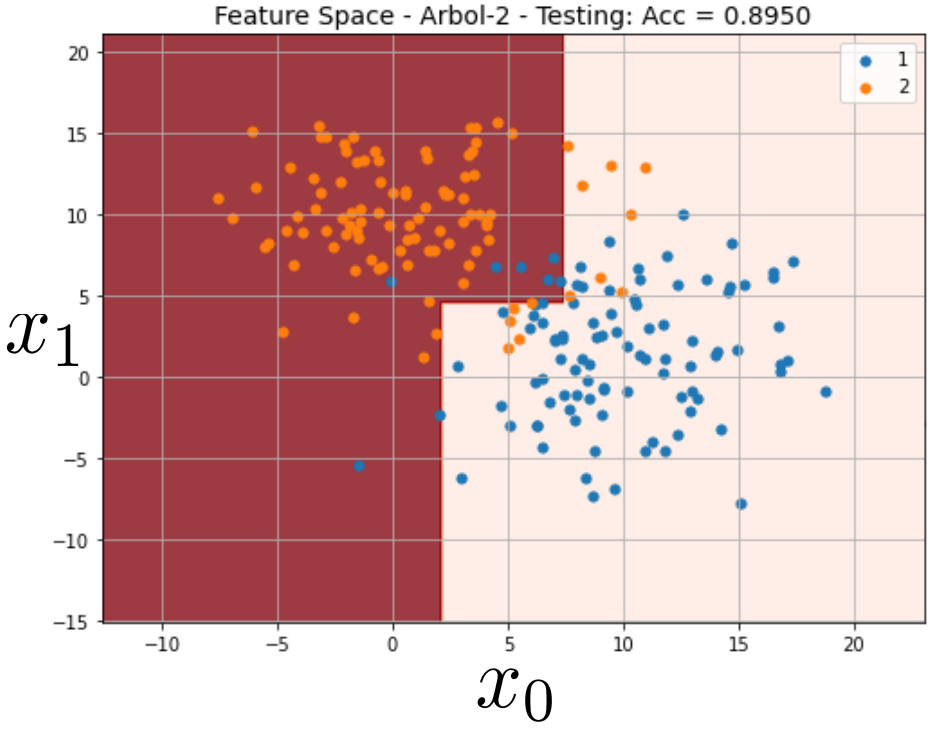

Feature Space - Arbol-1 - Testing: Acc = 0.8250
1
2
20
15
10
5
0
−5
−10
−15
−10
−5
0
5
10
15
20
x_1
x_0

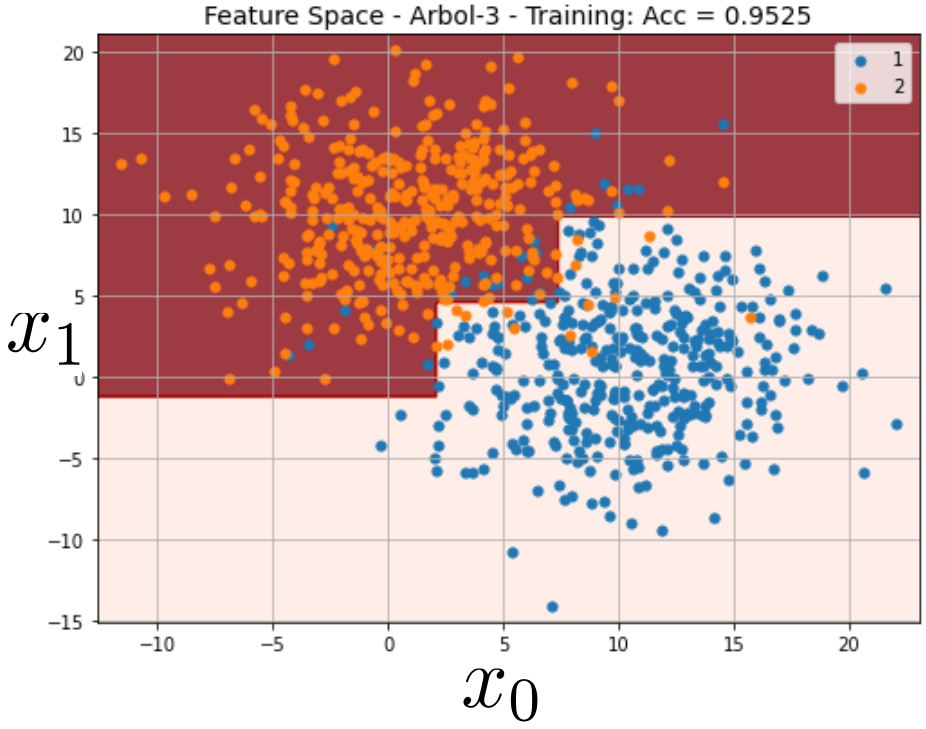

Feature Space - Arbol-2 - Training: Acc = 0.9425
1
2
x_1
x_0

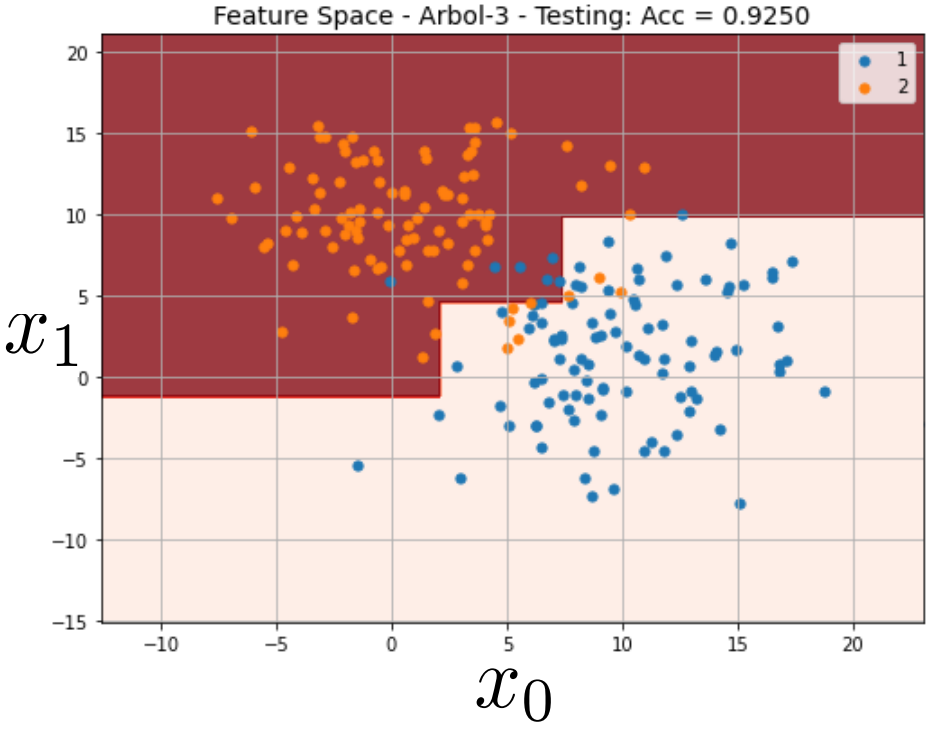

Feature Space - Arbol-2 - Testing: Acc = 0.8950
1
2
x_1
x_0

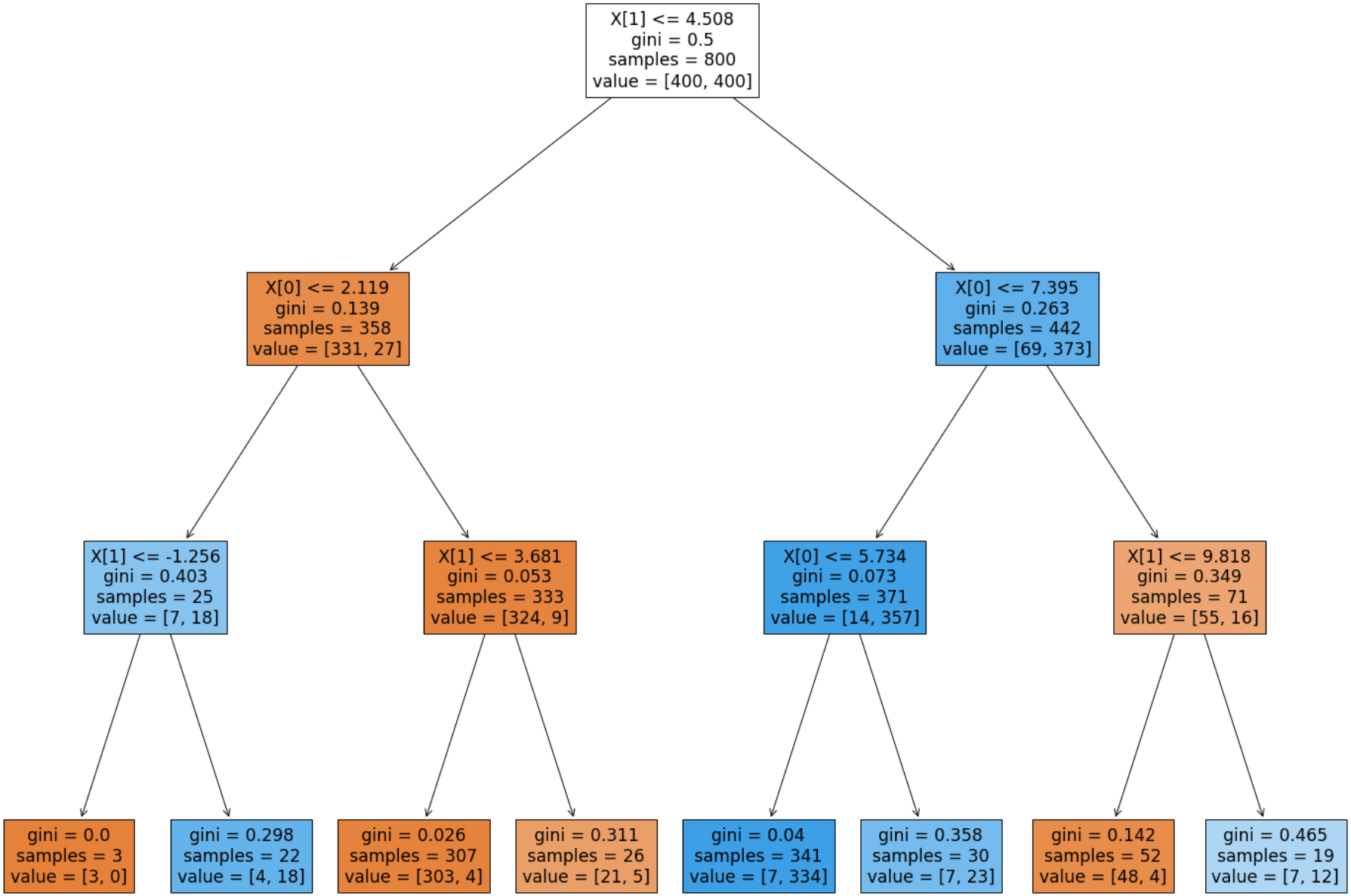

X[1] <= 4.508
gini = 0.5
samples = 800
value = [400, 400]
X[0] <= 2.119
gini = 0.139
samples = 358
value = [331, 27]
X[0] <= 7.395
gini = 0.263
samples = 442
value = [69, 373]
gini = 0.403
samples = 25
value = [7, 18]
gini = 0.053
samples = 333
value = [324, 9]
gini = 0.073
samples = 371
value = [14, 357]
gini = 0.349
samples = 71
value = [55, 16]

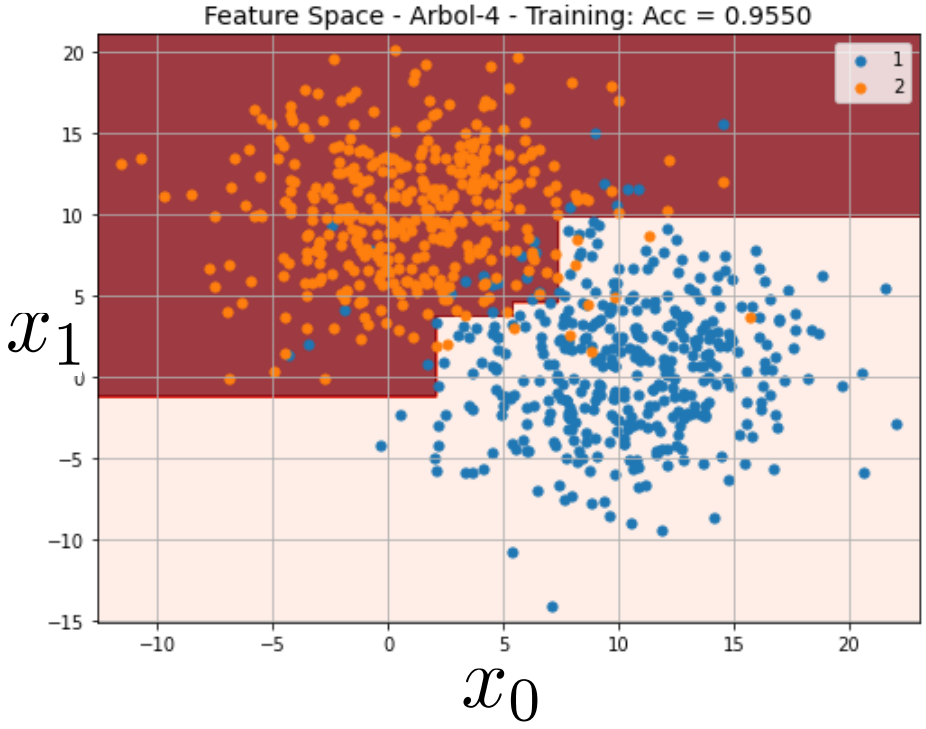

Feature Space - Arbol-2 - Training: Acc = 0.9425
1
2
x_1
x_0

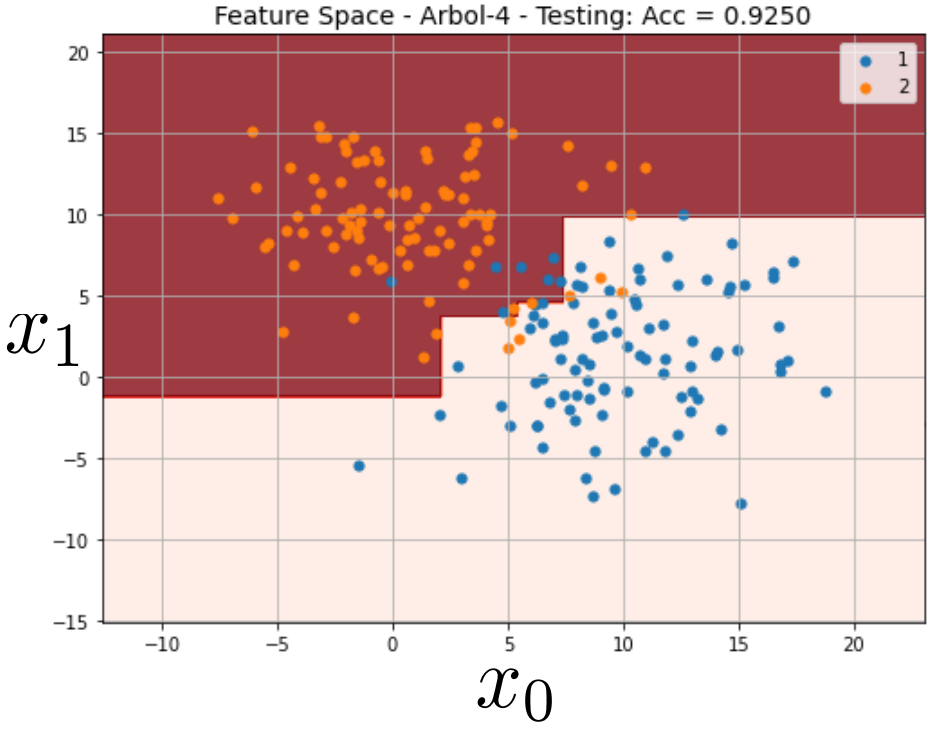

Feature Space - Arbol-2 - Testing: Acc = 0.8950
1
2
x_1
x_0

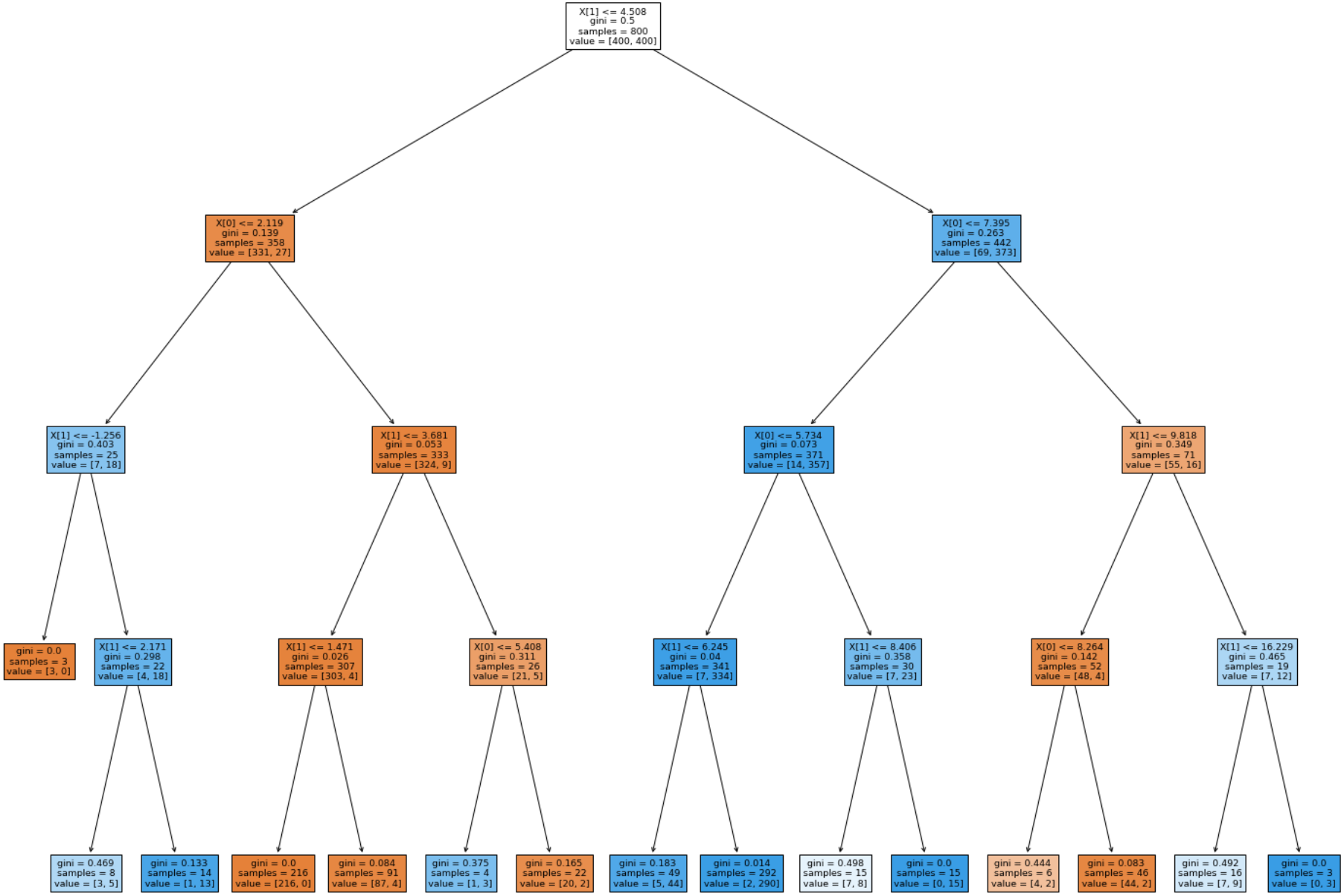

Feature Space - Arbol-3 - Training: Acc = 0.9525
1
2
20
15
10
5
0
−5
−10
−15
−10
−5
0
5
10
15
20
x_1
x_0

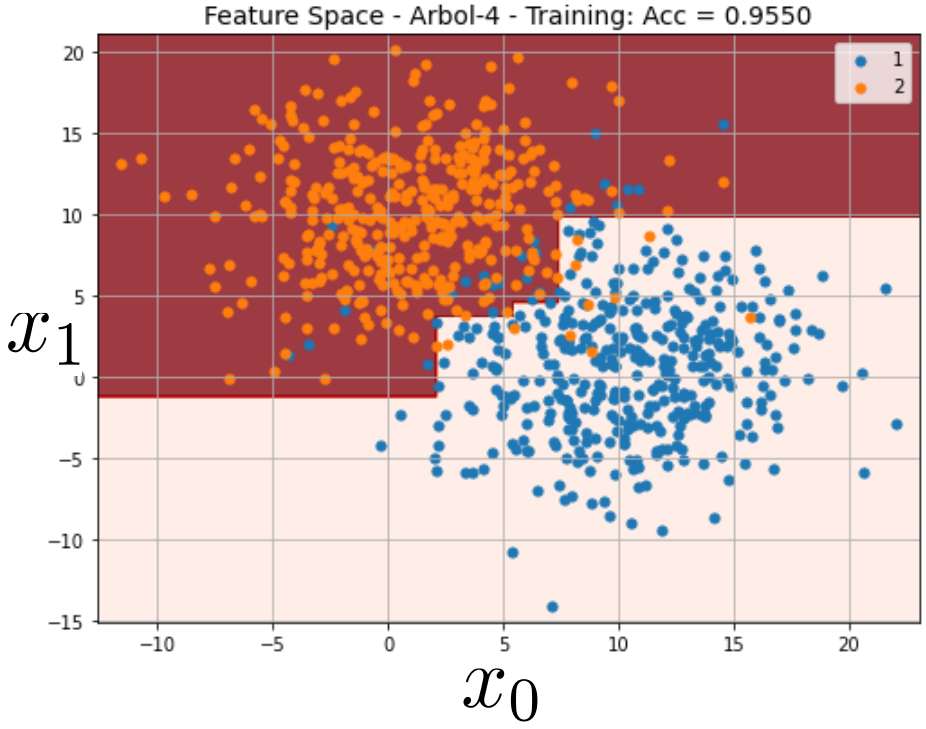

Feature Space - Arbol-3 - Testing: Acc = 0.9250
1
2
20
15
10
5
0
−5
−10
−15
−10
−5
0
5
10
15
20
x_1
x_0

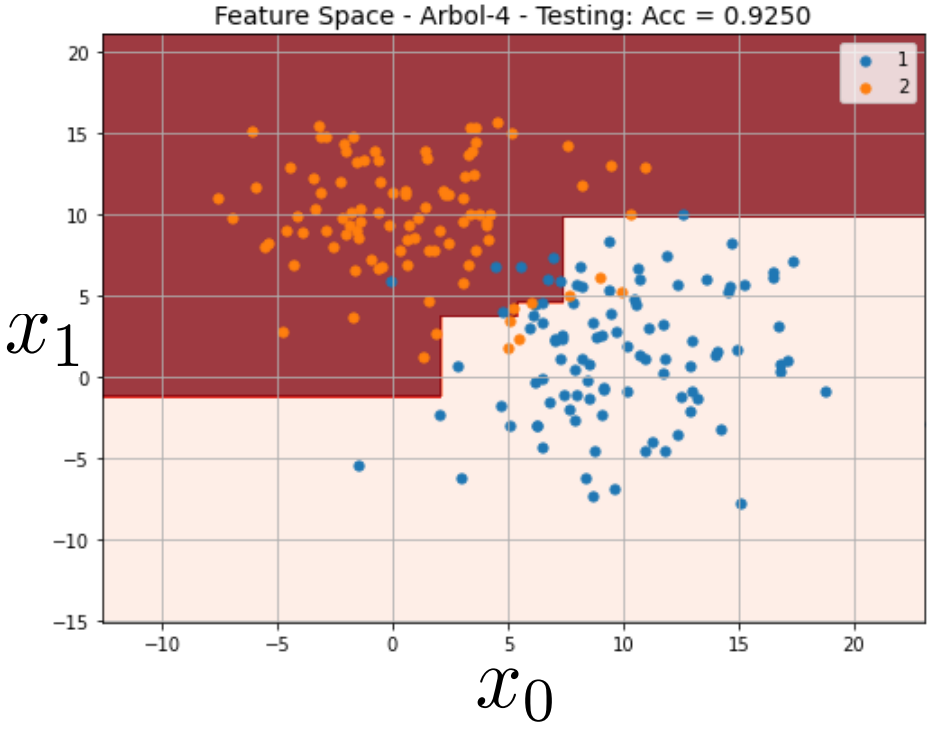

X[1] <= 4.508
gini = 0.5
samples = 800
value = [400, 400]
X[0] <= 2.119
gini = 0.139
samples = 358
value = [331, 27]
X[0] <= 7.395
gini = 0.263
samples = 442
value = [69, 373]
X[1] <= -1.256
gini = 0.403
samples = 25
value = [7, 18]
X[1] <= 3.681
gini = 0.053
samples = 333
value = [324, 9]
X[0] <= 5.734
gini = 0.073
samples = 371
value = [14, 357]
X[1] <= 9.818
gini = 0.349
samples = 71
value = [55, 16]
gini = 0.0
samples = 3
value = [3, 0]
gini = 0.298
samples = 22
value = [4, 18]
gini = 0.026
samples = 307
value = [303, 4]
gini = 0.311
samples = 26
value = [21, 5]
gini = 0.04
samples = 341
value = [7, 334]
gini = 0.358
samples = 30
value = [7, 23]
gini = 0.142
samples = 52
value = [48, 4]
gini = 0.465
samples = 19
value = [7, 12]

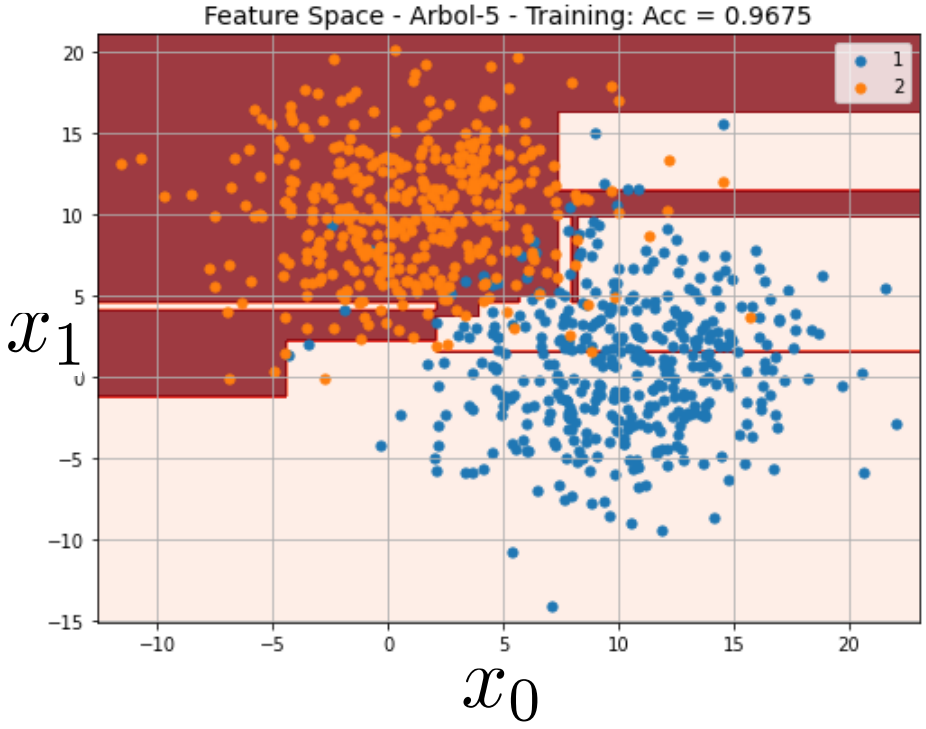

Feature Space - Arbol-4 - Training: Acc = 0.9550
1
2
x_1
x_0

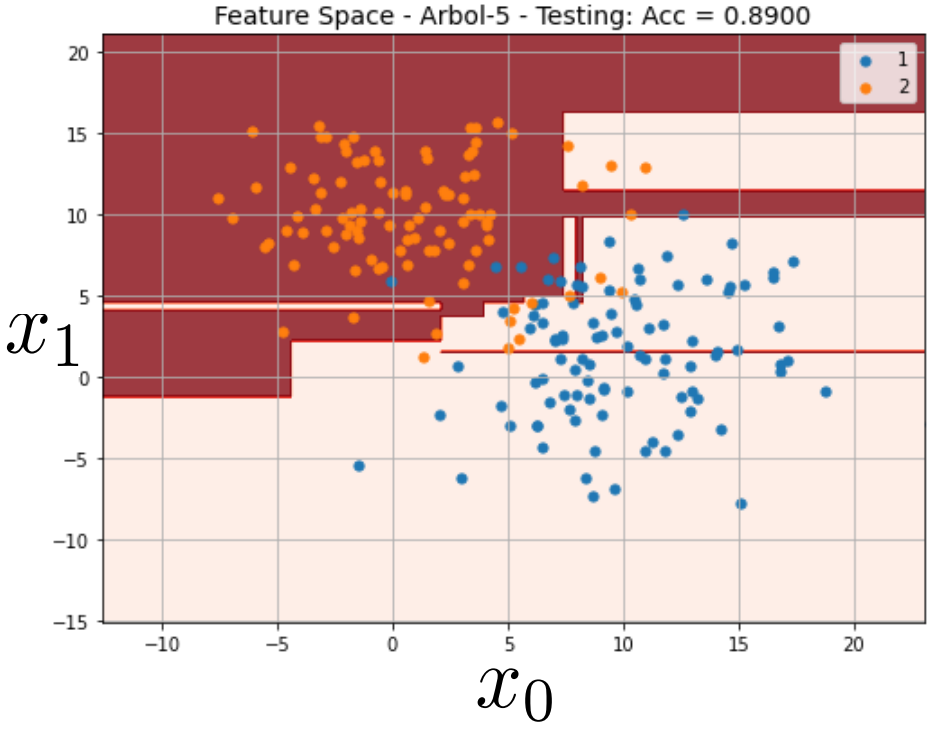

Feature Space - Arbol-4 - Testing: Acc = 0.9250
1
2
x_1
x_0

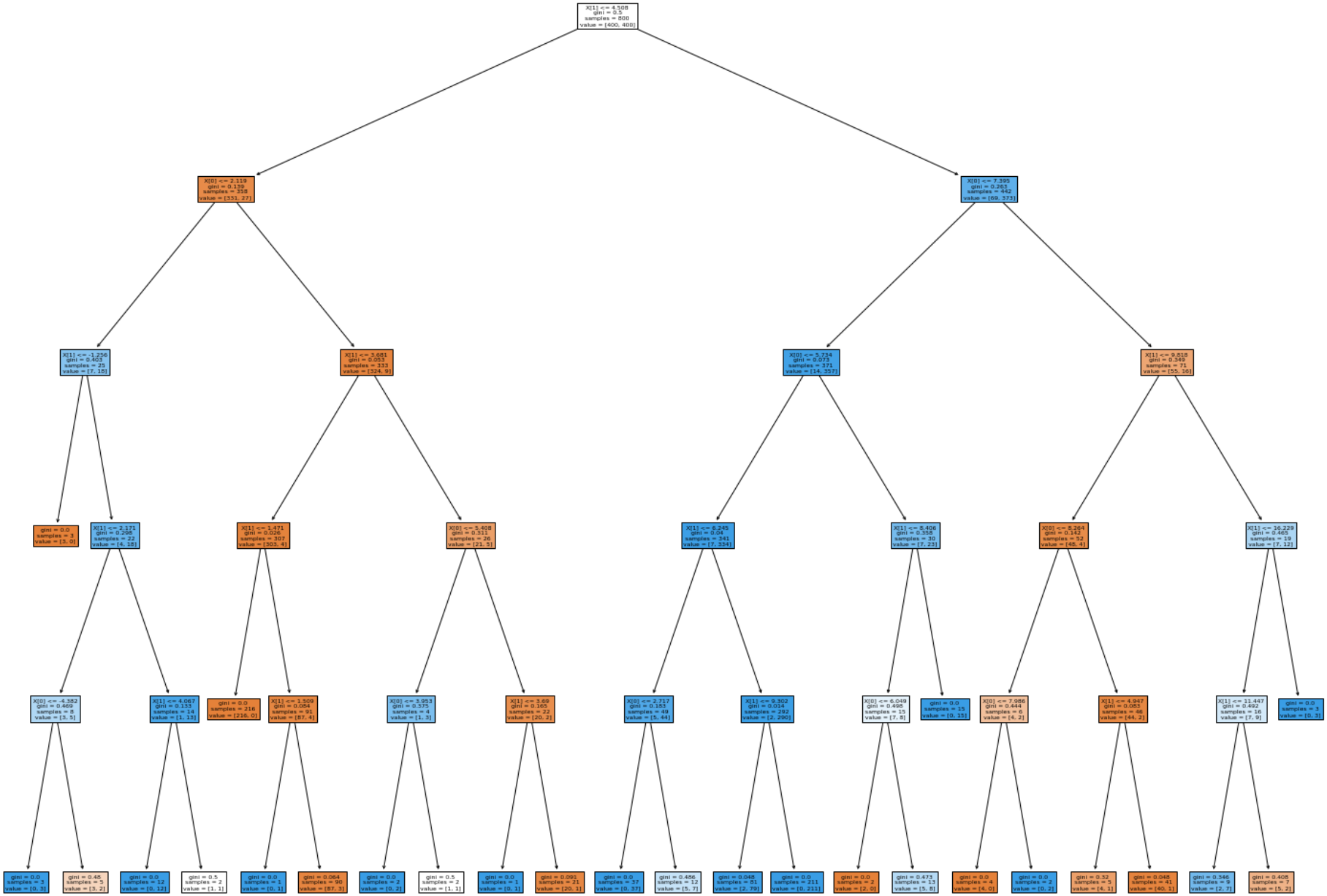

X[1] <= 4.508
gini = 0.5
samples = 800
value = [400, 400]
X[0] <= 2.119
gini = 0.139
samples = 358
value = [331, 27]
X[0] <= 7.395
gini = 0.263
samples = 442
value = [69, 373]
X[1] <= -1.256
gini = 0.403
samples = 25
value = [7, 18]
X[1] <= 3.681
gini = 0.053
samples = 333
value = [324, 9]
X[0] <= 5.734
gini = 0.073
samples = 371
value = [14, 357]
X[1] <= 9.818
gini = 0.349
samples = 71
value = [55, 16]
gini = 0.0
samples = 3
value = [3, 0]
X[1] <= 2.171
gini = 0.298
samples = 22
value = [4, 18]
X[1] <= 1.471
gini = 0.026
samples = 307
value = [303, 4]
X[0] <= 5.408
gini = 0.311
samples = 26
value = [21, 5]
X[1] <= 6.245
gini = 0.04
samples = 341
value = [7, 334]
X[1] <= 8.406
gini = 0.358
samples = 30
value = [7, 23]
X[0] <= 8.264
gini = 0.142
samples = 52
value = [48, 4]
X[1] <= 16.229
gini = 0.465
samples = 19
value = [7, 12]
gini = 0.469
samples = 8
value = [3, 5]
gini = 0.133
samples = 14
value = [1, 13]
gini = 0.0
samples = 216
value = [216, 0]
gini = 0.084
samples = 91
value = [87, 4]
gini = 0.375
samples = 4
value = [1, 3]
gini = 0.165
samples = 22
value = [20, 2]
gini = 0.183
samples = 49
value = [5, 44]
gini = 0.014
samples = 292
value = [2, 290]
gini = 0.498
samples = 15
value = [7, 8]
gini = 0.0
samples = 15
value = [0, 15]
gini = 0.444
samples = 6
value = [4, 2]
gini = 0.083
samples = 46
value = [44, 2]
gini = 0.492
samples = 16
value = [7, 9]
gini = 0.0
samples = 3
value = [0, 3]


Feature Space - Arbol-4 - Training: Acc = 0.9550
1
2
x_1
x_0


Feature Space - Arbol-4 - Testing: Acc = 0.9250
1
2
x_1
x_0


Feature Space - Arbol-5 - Training: Acc = 0.9675
1
2
x_1
x_0


Feature Space - Arbol-5 - Testing: Acc = 0.8900
1
2
x_1
x_0


X[1] <= 4.508
gini = 0.5
samples = 800
value = [400, 400]
X[0] <= 2.119
gini = 0.139
samples = 358
value = [331, 27]
X[0] <= 7.395
gini = 0.263
samples = 442
value = [69, 373]
X[1] <= 1.256
gini = 0.463
samples = 25
value = [7, 18]
X[1] <= 3.681
gini = 0.053
samples = 333
value = [324, 9]
X[0] <= 3.734
gini = 0.075
samples = 371
value = [14, 357]
X[1] <= 9.818
gini = 0.349
samples = 71
value = [55, 16]
gini = 0.0
samples = 3
value = [3, 0]
X[1] <= 2.171
gini = 0.298
samples = 22
value = [4, 18]
X[1] <= 1.471
gini = 0.026
samples = 307
value = [303, 4]
X[0] <= 5.408
gini = 0.311
samples = 26
value = [21, 5]
X[1] <= 8.245
gini = 0.04
samples = 341
value = [7, 334]
X[1] <= 8.406
gini = 0.355
samples = 30
value = [7, 23]
X[0] <= 8.264
gini = 0.142
samples = 52
value = [45, 4]
X[1] <= 16.229
gini = 0.465
samples = 19
value = [7, 12]
X[0] <= -4.382
gini = 0.469
samples = 8
value = [3, 5]
X[1] <= 4.067
gini = 0.133
samples = 14
value = [1, 13]
gini = 0.0
samples = 216
value = [216, 0]
X[1] <= 1.509
gini = 0.054
samples = 91
value = [87, 4]
X[0] <= 3.953
gini = 0.375
samples = 4
value = [1, 3]
X[1] <= 3.69
gini = 0.165
samples = 22
value = [20, 2]
X[0] <= 2.717
gini = 0.163
samples = 48
value = [5, 43]
X[1] <= 9.302
gini = 0.014
samples = 292
value = [2, 290]
X[0] <= 6.049
gini = 0.498
samples = 15
value = [7, 8]
gini = 0.0
samples = 15
value = [0, 15]
X[0] <= 7.986
gini = 0.444
samples = 6
value = [4, 2]
X[1] <= 4.917
gini = 0.083
samples = 46
value = [44, 2]
X[1] <= 11.447
gini = 0.492
samples = 16
value = [7, 9]
gini = 0.0
samples = 3
value = [0, 3]
gini = 0.0
samples = 3
value = [3, 0]
gini = 0.48
samples = 5
value = [3, 2]
gini = 0.0
samples = 12
value = [0, 12]
gini = 0.5
samples = 2
value = [1, 1]
gini = 0.0
samples = 1
value = [0, 1]
gini = 0.064
samples = 90
value = [87, 3]
gini = 0.0
samples = 2
value = [0, 2]
gini = 0.5
samples = 2
value = [1, 1]
gini = 0.0
samples = 1
value = [0, 1]
gini = 0.091
samples = 21
value = [20, 1]
gini = 0.0
samples = 37
value = [0, 37]
gini = 0.486
samples = 12
value = [5, 7]
gini = 0.048
samples = 81
value = [2, 79]
gini = 0.0
samples = 211
value = [0, 211]
gini = 0.0
samples = 2
value = [2, 0]
gini = 0.473
samples = 13
value = [5, 8]
gini = 0.0
samples = 4
value = [4, 0]
gini = 0.0
samples = 2
value = [0, 2]
gini = 0.32
samples = 5
value = [4, 1]
gini = 0.048
samples = 41
value = [40, 1]
gini = 0.346
samples = 8
value = [2, 7]
gini = 0.408
samples = 7
value = [5, 2]

Random Forest

Random Forest

TRAINING:

for i = 1 to n

Escoger aleatoriamente un subconjunto de training

Entrenar un árbol de decisión A_i

Random Forest

TRAINING:

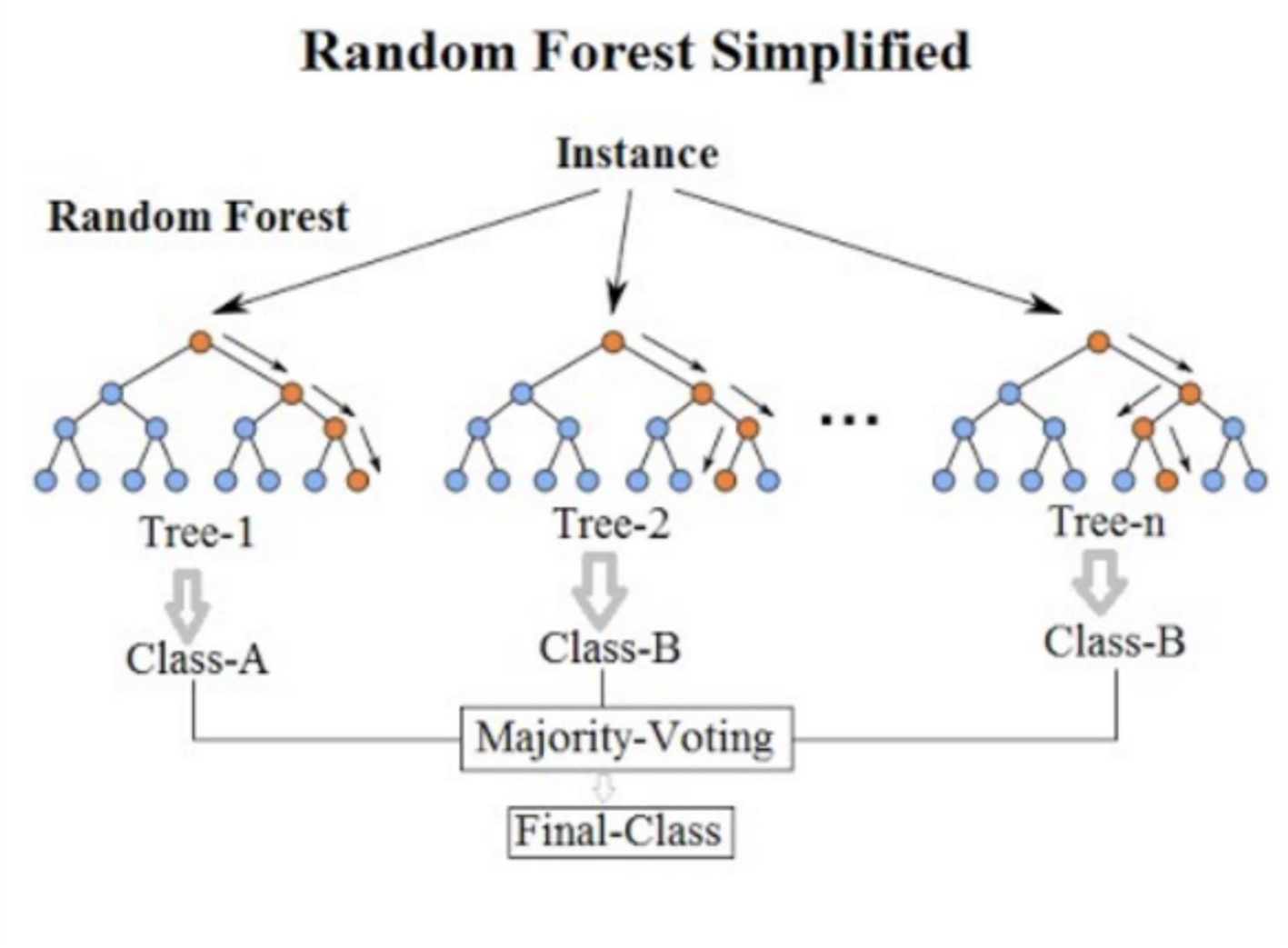
for i = 1 to n
    Escoger aleatoriamente un subconjunto de training
    Entrenar un árbol de decisión A_i

TESTING:

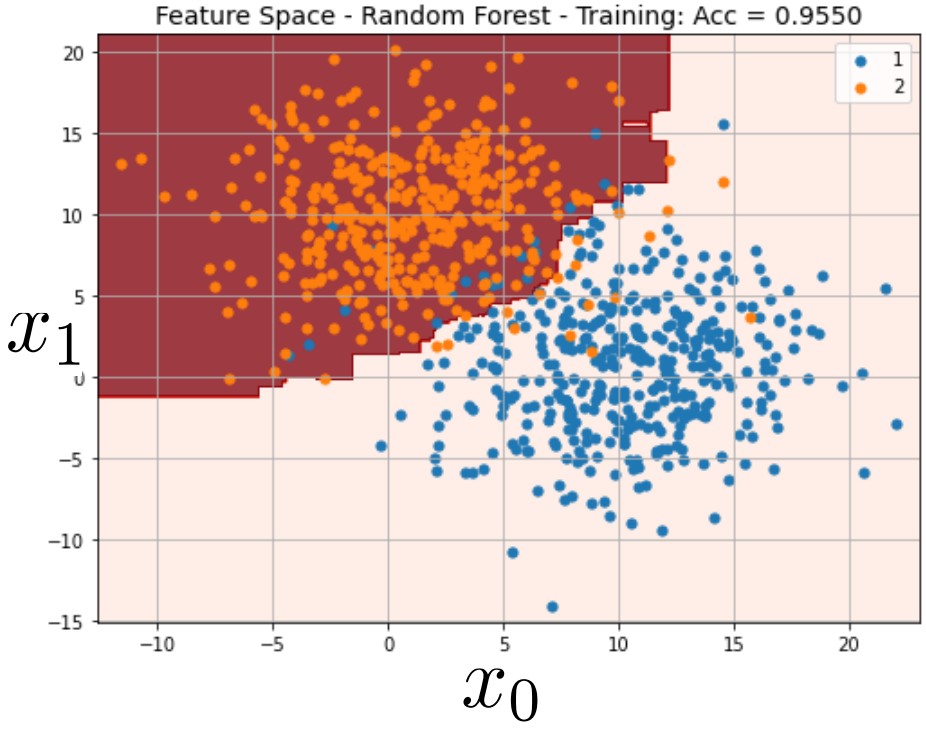
for i = 1 to n
    Clasificar la muestra de testing usando A_i

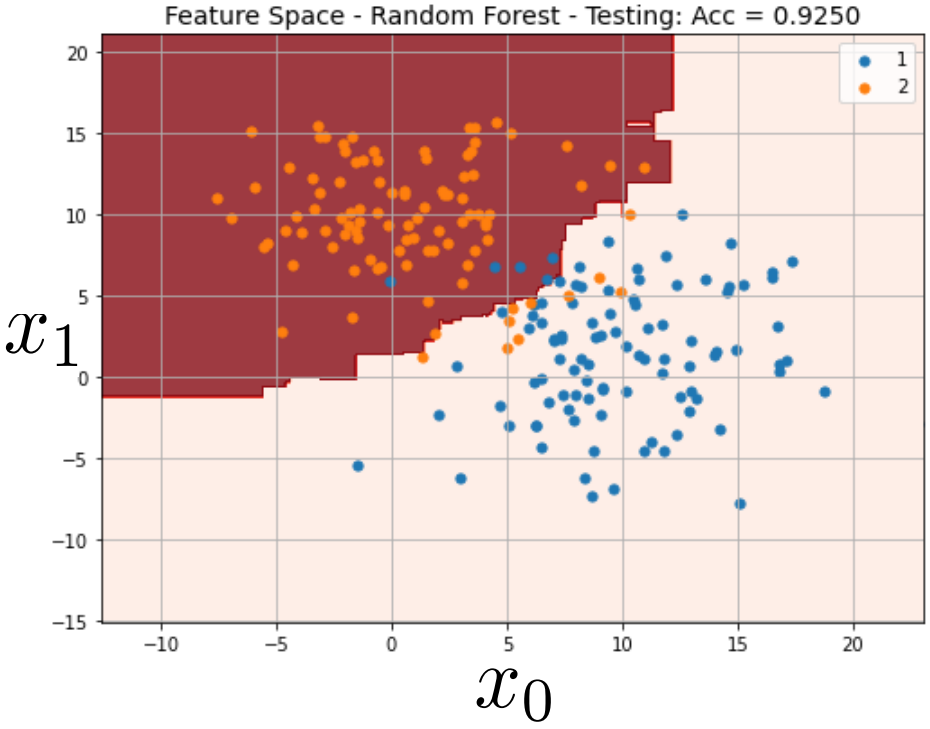
Clasificar la muestra según la mayoría de los n votos

Random Forest



https://en.wikipedia.org/wiki/Random_forest


Feature Space - Random Forest - Training: Acc = 0.9550
1
2
x_1
x_0


Feature Space - Random Forest - Testing: Acc = 0.9250
1
2
x_1
x_0